THE MINES MAGAZINE

JANUARY 1960

- Geochemical Prospecting
- Carnival in the High Andes
- Electrical Concentration of Minerals
- Kerr-McGee Mineral Development and Research
- Explosive Working of Metals

CLASS NOTES

When advising us of change of address, please confirm your position or title and company affiliation.

1882-1930

Robert McCart, Jr., '05, mining consultant, may be addressed at 5028 Bryce Ave., Ft. Worth 7, Texas.

Ernest E. Thum, '06, has moved from Cleveland, Ohio, to Metals Park, Novelty, Ohio.

Charles E. Prior, '13, mining director, Western Gold & Uranium, lives at 12301 1st Helena Dr., Los Angeles 49, Calif.

Frank T. A. Smith, '16, is living at 457 Calle Mayor, Redondo Beach, Calif.

Kenneth S. Ferguson, '17, gives his mailing address as P.O. Box 506, La Jolla, Calif.

Victor J. Lynch, '20, mining engineer, U. S. Bureau of Mines, is living at 3814 Woodlake Dr., Knoxville 18, Tenn.

Thomas J. Clifford, '21, general mill superintendent, St. Joseph Lead Co., gives his address as Route 2, Bonne Terre, Mo.

John A. Poulin, '21, executive for Sinclair Oil Corp., lives at 4 East 70th St., New York 21, N. Y.

Walter Mayer, '22, senior engineer for Cook County Highway Department, lives at 7820 Linder Ave., Morton Grove, Ill.

Ethbert F. Reed, '22, chief geologist for Inspiration Consolidated Copper Co., may be addressed at Box 103, Inspiration, Ariz.

K. W. Powers, '25, branch manager for Timken Roller Bearing Co., lives at 1645 Swift Ave., Kansas City 16, Mo.

Arch F. Boyd, '26, is mining engineer for Atomic Energy Commission with mailing address at 1520 E. Sherwood Dr., Grand Junction, Colo.

H. W. Haight, '27, vice president and director of Humble Oil & Refining Co., has changed his mailing address from Tulsa, Okla., to Box 2180, Houston 1, Texas.

Field M. Davis, '28, president of Davis & Bates, Inc., may be addressed at 1724 Milam Bldg., San Antonio, Texas.

James B. Saunders, '30, has moved from Gunnison, Colo., to Telluride, Colo. His P. O. Box number is 51.

1931-'40

Gaylord R. Chase, '32, has been an M.D. since 1939. He lives at 2819 Hayden St., Amarillo, Texas.

Warren D. Caton, '35, is concentrator test engineer at the Ajo plant of Phelps Dodge on hatch or pilot plant flotation testing including calculations and reports of the work.

Jean W. Pressler, '36, is metallurgical advisor for U. S. Bureau of Mines & I.C.A., Seoul, Korea. His mailing address is USOM/Korea, American Embassy, APO 301, San Francisco, Calif.

Arthur W. Heuck, '36, has asked to have his mailing address changed from French Guiana to 1077 Elm Ave., Long Beach 13, Calif.

W. Bruce Barbour, '37, consulting petroleum engineer, may be addressed at 911 Southwest Bldg., Houston 2, Texas.

William M. Baxter, '39, has moved from Webster Grove, Mo., to 902 Tuxedo Blvd., St. Louis 19, Mo.

T. L. Goudvis, '40, president of Concrete Masonry Corp., may be addressed at Portage Dr., Vermilion, Ohio.

1941-'45

Frank B. Harris, '41, branch manager for Ingersoll-Rand Co., has moved from Los Angeles to 17 Martin Lane, Englewood, Colo.

A. Leonard Smith, '41, is materials engineer for ICA with mailing address c/o American Embassy (USOM), Colombo, Ceylon.

William R. Peery, '42, has moved from Denver to 5295 S. University Blvd., Littleton, Colo.

Richard H. Shaw, '42, has moved from Denver to Palo Alto, Calif., where he may be addressed c/o Coronado Engineering Co., Redwood Bldg., 800 Welch Rd.

Irwin M. Glasser, '43, has moved from Corpus Christi to Pleasanton, Texas, where he is district supervising engineer (a newly created position) for Humble Oil & Refining Co. His address is Box 117.

1946-'50

J. G. Cunningham, '47, was transferred by Cal-Tex from Wapet, West Australia to Overseas Services, Philippines, in June 1959. His present address is c/o Overseas Services (Phil.) Inc., P.O. Box 1713, Manila, Philippines.

S. Norman Domenico, '48, division geophysical technical supervisor for Pan American Petroleum Corp., lives at 444 7th Ave. S.W., Calgary, Alberta, Canada.

William F. McNamara, '48, construction management engineer for the Department of Interior, is living at 922 Adams N.E., Albuquerque, N. M.

Guinn E. Metzger, '48, is an exchange student in Germany doing graduate work for Los Alamos. His address is Verlautenheide by Aachen, Haarenerstrasse VI, Germany.

Gilbert D. Borthick, Jr., '48, process engineer for Bay Petroleum Corp., has moved from Enid, Okla., to 5465 Flower Ct., Arvada, Colo.

Dr. Russell C. Nelson, '49 and '51, and his wife (the former Miss Dorothy Prouse of Golden) announce the birth of a son, Jeffrey Scott, on Dec. 3. Dr. Nelson is engineer-in-charge, metallurgical laboratory, Sylvania Electric Products, Inc. The Nelsons live at 208 Poplar St., Towanda, Pa.

Denman S. Galbraith, '49, is consulting geologist with mailing address at 410 Colorado Bldg., Denver 2, Colo.

Hugh J. Matheson, '49, owner of Chandalar Mining Co., Ft. Yukon, Alaska, lives at 1075 Riverview Dr., Fairbanks, Alaska.

J. H. Pittinger, '49, division exploration manager for Shell Oil Co., has been transferred from Houston to Corpus Christi, Texas, with mailing address c/o Shell Oil Co., Box 1861.

William D. Baker, '49, general superintendent for ASARCO at Parral, Chih., Mexico, has been laid up for 21 weeks with a broken leg and is just entering the hospital for another leg operation and 18 more weeks of recuperation. Crutches and casts do not appeal to Bill. He is addressed at Apartado 85.

William L. Robbins, '49, is senior engineer for Creole Petroleum Corp. with mailing address c/o Creole Petr. Corp., Ing. de Petr., Tia Juana, Zulia, Venezuela.

Walter H. Ortel, '49, independent geologist, has moved from Lubbock, Texas to 1870 Iris, Denver 15, Colo.

Donald I. Andrews, '50, has resigned as district geologist for Continental Oil and has accepted a position as consultant with Rodgers, Seglund and Shaw Assoc., oil and gas consultants. His office address is 1405 Pere Marquette Bldg., New Orleans, La.

Arthur W. Wadman, Jr., '50, division exploitation geologist for Sunray Midcontinent Oil Co., has moved from Tulsa to 6140 Hoyt St., Arvada, Colo.

M. I. Signer, Jr., manager of Potash Division of International Mineral & Chemical Corp., has returned from a trip to Europe where he was on business for his company. He visited Germany, France and Holland. His mailing address is Box 299, Esterhazy, Sask., Canada.

1951

Harold W. Blakely has moved from Delta, Colo., to 254 S. Tusher, Moab, Utah.

Dr. John C. Hagen is supervising geologist for Midwest Ore Co. (The Hanna Mining Co.) with mailing address at Iron Mountain, Mo.

Victor Inman, geologist-observer for Standard Oil Co. of Texas, has moved from Cuero to Alice, Texas. His P.O. Box number is 957.

Raymond M. Loeb, Jr., is petroleum research engineer for ARAMCO with mailing address c/o Arabian American Oil Co., Abqaiq No. 669, Dhahran, Saudi Arabia.

William B. Milliken III is research engineer for Litton Industries with mailing address 19910 Gresham St., Northridge, Calif.

Wesley H. Parker's address is 16 Stark, Phillips, Texas.

George H. Warburton, geophysicist for Humble Oil and Refining Co., lives at 3927 Lisa Lane, Shreveport, La.

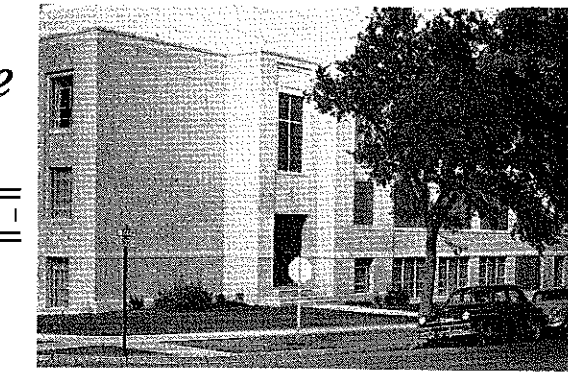
1952

Jackson Wayne Brown is employment director for Geophysical Service Inc. with

(Continued on page 16)

The Mines Magazine

Volume L January, 1960 Number 1



CONTENTS—

DEPARTMENTS—

ADVERTISERS' LISTINGS—PAGE 45

FRONT COVER—

The 4000-ton per day mill at St. Patrick's Copper Mines, Ltd., Eire, was a project of Denver Equipment Co. Ltd. of London which supervised the design, construction and equipment installation for Irish Copper Mines Ltd. of Toronto. Ore contains one per cent copper and seven per cent sulphur. Ancient mine workings may be seen in the background.

Official Organ of and Copyright 1960 by the Colorado School of Mines Alumni Association, Inc. Entered as Second Class matter at the Postoffice at Golden, Colorado, under the Act of Congress of March 3, 1879. Subscription price $5.00 per year U.S. and Possessions. Single copies 75 cents, except special editions. $1.00 additional charge outside U.S. and Possessions. Published every month in the year by the Colorado School of Mines Alumni Association. Address all correspondence relating to the Mines Magazine to L. Carter Kaanta, Editor, 1612 Illinois St., Golden, Colorado.

NEWS of the MINERAL INDUSTRIES

Kerr-McGee, AEC Sign New Five-Year Contract

An extended uranium concentrate purchase contract was signed recently by Kerr-McGee Oil Industries, Inc., of Oklahoma City, and the U. S. Atomic Energy Commission, for continued operation of the 300-ton-per-day uranium processing mill at Shiprock, N. Mex.

The new contract will run from Nov. 1, 1959, to June 30, 1965, or to an earlier date when Kerr-McGee will have delivered to the Commission the maximum number of pounds of uranium concentrate provided in the contract. The mill has operated since 1954 under a contract with the AEC which terminated Oct. 31, 1959.

The plant is shut down at present for the construction of a new solvent extraction circuit to recover high purity vanadium concentrate (about 99 per cent V_2O_5) as well as uranium concentrate (U_3O_8) from the Shiprock ores. Construction is being carried on for the most part by workers regularly employed in the mill's operating force.

Approximately 85 per cent of the uranium ores processed by the Shiprock mill come from mines on the Navajo Indian Reservation. Most of the persons employed at the mill and at the company's mines in the Lukachukai mountains are Navajo Indians.

Pollucite Ore Developed In Southern Rhodesia

An extensive deposit of high grade pollucite ore has been developed at the Southern Rhodesia, Africa, operations of Bikita Minerals (Private) Ltd., according to an announcement by American Potash & Chemical Corp., which handles the sale of Bikita products.

Tests indicate the deposit is one of the largest in the world and offers a reliable supply of low-cost pollucite, which is aluminum-cesium silicate, for cesium applications in such industries as glass and ceramics manufacturing, in welding rod fluxes and other uses where silica can be utilized along with the cesium. Pollucite in the Bikita deposit averages 24.4 per cent cesium oxide.

Cesium in the past has been available only in small quantities until American Potash recently began sales of cesium metal and cesium compounds produced from lepidolite lithium ore at San Antonio, Texas.

Canon City Uranium Plant to Be Enlarged

The Atomic Energy Commission and the Cotter Corp., of Santa Fe, N. Mex., recently signed a uranium purchase contract which will result in the expansion of the Cotter Corp's pilot plant at Canon City, Colo., to a full-scale uranium processing mill. The plant's daily rated capacity will be increased from about 50 tons a day to approximately 200 tons a day.

This is another action by the Commission to implement the policy announced on April 2, 1958, which authorized a limited expansion of domestic uranium procurement in order to provide markets for those areas which had no market or an inadequate market for developed ore reserves. This announcement indicated that a 200 ton-a-day mill would be required for Colorado Front Range ores.

The new contract provides a market for a number of producers whose properties hereafter are "dedicated" to the Canon City mill. Other properties may be added at the Commission's option.

Exploration Assistance Available in Central States

Although the Office of Minerals Exploration Region IV Office in Joplin, Mo., was closed in August 1959, OME exploration assistance is still available in the seven Central States which comprise that region.

OME activities in Kansas, Oklahoma, and Texas, are now administered by the Region III Office, Denver Federal Center, Denver 25, Colo., and activities in Arkansas, Louisiana, Mississippi, and Missouri, are administered by the Region V Office, Post Office Bldg., Knoxville 2, Tenn.

Anaconda Co. Uranium Mill Contract Extended to 1966

A uranium concentrate purchase contract between the Atomic Energy Commission and the Anaconda Co., operator of the Bluewater, N. M., uranium processing mill, has been extended to Dec. 31, 1966. The new contract is effective as of May 1, 1959. The current contract would

(Continued on page 9)

MINERAL INDUSTRIES

(Continued from page 6)

have terminated on March 31, 1962.

The Anaconda contract provides for a deferral, or "stretch-out" of a substantial portion of the pre-1962 production to the 1962-1966 period. Approximately 4,000,000 pounds of U_3O_8 will be deferred to the 1962-1966 period under the new contract.

Under the stretch-out plan, the Bluewater mill will operate six days a week at a rate of up to about 3,000 tons of ore a day, depending upon the grade of ore processed. Formerly, the mill operated seven days a week at a daily rate of about 3,500 tons of ore. When Anaconda completes concentrate deliveries under the contract in 1966, the company will have mined and processed less than half of its ore reserves which were developed prior to Nov. 24, 1958.

Corporate offices of the Anaconda Co. are at 25 Broadway, New York, N. Y., with western offices at Butte, Mont. Albert J. Fitch, Bluewater, is manager of the New Mexico operations.

Bureau of Mines Continues Phosphate-Rock Research

Further tests with the Bureau of Mines phosphate-rock planer in Idaho during the 1960 fiscal year, which began July 1, were announced by Bureau Director, Marling J. Ankeny. The study is part of a program to increase recovery of phosphate. A related project will cover improved beneficiation methods for both western and southeastern phosphate rock.

Field tests with the phosphate planer indicate that its chisels, used to cut rock from the mining face, must be modified. When the changes are made, experiments will be conducted in cooperation with producing companies in the Western phosphate-rock field of Idaho, Montana, Utah, and Wyoming, Ankeny said.

Because they cannot be upgraded by present methods, large tonnages of phosphate rock in the Western field now are bypassed and the Bureau seeks beneficiation techniques that will make them commercially attractive, the Director added.

The Bureau also is continuing investigations to determine the chemical and physical nature of Florida and Tennessee phosphate slimes and to develop possible processes for using them. Under present practice, these slow-settling slimes, which contain nearly as much phosphate as the original ore, are wasted. The 10 million tons discarded annually requires large acreages of high-value land for storage.

Ankeny said the Bureau's research on the phosphate-rock planer will be centered at Spokane, Wash. and that beneficiation tests on Western phosphate rock are to be conducted at Albany, Ore., and those on phosphate-rock slimes at Tuscaloosa, Ala.

Aluminum Smelters Salvage 7 Billion Pounds of Metal

Through research and advancements in the art of alumnium smelting during the past decade, a total of more than 7 billion pounds of scrap alumnium has been salvaged, processed into alloys and returned to American industry for a wide variety of uses it was reported recently by the Aluminum Smelters Research Institute, Chicago.

The Institute predicted that, through expanding knowledge of metallurgy, more than 15 billion pounds will be returned to the nation's aluminum users during the next 10 years.

The conservation and re-use of scrap aluminum has literally saved the U. S. economy billions of dollars, the Institute stated. It pointed out that, without the salvage of 7 billion pounds since 1948, American users, in duplicating the output with virgin aluminum, would have been forced to:

Import 13 million tons of bauxite.

Ship the bauxite to the U. S. in 1300 voyages at 10,000 tons per trip.

Ship to plants 10 million tons of alumina, coke, pitch, cryolite, soda ash, and other ingredients.

Construct additional facilities to process the metal into ingot form.

Consume 67 billion kilowatt hours of electrical power—an amount equal to all electricity generated in the U. S. in about a five-week period.

AEC Extends Contract With Union Carbide

The Atomic Energy Commission has extended until June 30, 1964, a cost-plus-fixed-fee contract with Union Carbide Corp. for operation of four major Commission facilities, S. R. Sapirie, manager of the Commission's Oak Ridge operations, announced recently.

Union Carbide Nuclear Co., division of Union Carbide Corp., operates two large production plants and a research and development laboratory in Oak Ridge, Tenn., and the gaseous diffusion plant at Paducah, Ky. The present contract for operation of these facilities was to expire June 30, 1960, but was extended for four years.

TECHNICAL SOCIETIES and ASSOCIATIONS

Western Mining Conference Scheduled for Mar. 17-19

The National Western Mining Conference, co-sponsored by the Colorado Mining Assn. and the Denver Chamber of Commerce, will be held March 17-19 in Denver's new Hilton Hotel.

About 2000 representatives of the mining industry are expected to attend the three-day session.

Frank J. Windolph, executive of Climax Molybdenum Co., is chairman of the Planning Committee; John Wise, general manager of Idarado Mining Co. of Ouray, is vice chairman.

Flat-Rolled Products Theme Of AIME Conference Jan. 20

Flat-rolled products, semi-finished and finished, will be the theme of a conference at the Del Prado Hotel, Chicago, Jan. 20, sponsored by the Mechanical Working Committee, Iron and Steel Division, The Metallurgical Society of AIME. The Chicago Section of AIME is co-sponsor. The Committee's first conference was held last year in Chicago.

Thomas Collins, assistant managing editor of the Chicago Daily News, will be luncheon speaker. His subject will be "How Business and Professional Men Must Prepare for Retirement."

Technical papers will be presented on such subjects as "Machine Scarfing," "Selecting of Ingot and Slab Sizes for the Modern Strip Mill," "Scaling Problems in Hot Strip Rolling," "Temper Rolling and Its Effect on Stretcher Strain Sensitivity," "Unitized Automobiles," "Processing and Properties of Magnetic Materials."

GSA Elects Officers

Dr. Hollis D. Hedberg, vice president, Exploration, of Gulf Oil Corp., was elected president (Nov. 4) of the Geological Society of America. Thomas B. Nolan of the United States Geological Survey, Washington, D. C., was elected vice president and the following were elected Councilors: Harold L. James, also of the U. S. G. S.; Vincent C. Kelley, University of New Mexico; George D. Woollard, University of Wisconsin; and Norman D. Newell, Columbia University.

Geologists Will Convene In Billings, Feb. 7-10

Over 1000 geologists from throughout the Rocky Mountain Empire will convene in Billings, Mont., Feb. 7-10, 1960, for the annual Rocky Mountain Section meeting of the American Association of Petroleum Geologists.

Theme for the annual event is "Future Exploration After a Decade of Progress." Approximately 33 technical papers will be presented by prominent geologists from the Rockies. General chairman for the meeting is James O. Staggs, division geologist for McAlester Fuel, Billings.

Social events for the meeting will include the President and General Chairman's reception Monday evening, Feb. 8, and a social hour and dinner dance on Tuesday evening. There will be special programs for the ladies Monday afternoon and Tuesday.

Awards Will Be Presented At AIME Meeting Feb. 14-18

Men receiving awards at the annual meeting of AIME in New York City, Feb. 14-18, will be Charles M. White, chairman of the board and chief executive officer of Republic Steel Corp., Benjamin F. Fairless Award; Lester Charles Uren, professor emeritus of petroleum engineering, University of California, Mineral Industry Education Award; Raymond E. Salvati, president of the American Mining Congress and president of Island Creek Coal Co., Erskine Ramsay Gold Medal; Robert J. Linney, executive vice president and executive committee member of the Reserve Mining Co., William Lawrence Saunders Gold Medal; Dr. Louis B. Slichter, director of the Institute of Geophysics at the University of California in Los Angeles, 1959 Daniel C. Jackling Award and Jackling Lecturer; Louis S. Renzoni, R. C. McQuire and W. Vernon Barker for their paper, "Direct Electrorefining of Nickel Matte," Extractive Metallurgy Division Award; Samuel H. Dolbear, consulting mining engineer and geologist, Hal Williams Hardinge Award.

C. R. Kuzell Will Deliver Metallurgy Lecture at AIME

The Metallurgical Society of AIME has announced that Charles R. Kuzell, of Douglas, Ariz., director of the Phelps Dodge Corp., will deliver the 1960 Extractive Metallurgy Lecture at the annual meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers to be held in New York, Feb. 14-18.

Kuzell, a former director of AIME, was the recipient in 1956 of one of the Institute's major awards, the James Douglas Gold Medal, established in 1922 in honor of Dr. James Douglas, twice AIME President. Kuzell received the award "for outstanding contributions to nonferrous metallurgy, particularly in the field of copper smelting; for inspiring and guiding young engineers, and for notable service to his professional society."

The first AIME lecture in extractive metallurgy, sponsored by the Extractive Metallurgy Division of The Metallurgical Society, was given at the national convention in San Francisco last February. Kuzell's theme will be the development of modern copper smelting.

Making New Class of Alloys Demonstrated in Research

The feasability of making a promising new class of metallic materials has been demonstrated in research at Battelle Memorial Institute, Columbus, Ohio.

The new materials, prepared in research sponsored by the Lead Industries Association, are "lead-cemented" alloys made by mixing molten lead with finely divided solid particles of other metals or materials. The result is a material combining the properties of both lead and the second substance, usually a metal. Such combined-property materials may be useful in a variety of applications according to research metallurgists Dr. Dean N. Williams, Jerry A. Houck, and Dr. Robert I. Jaffee.

For example, lead is effective in stopping gamma rays when used in nuclear radiation shielding. With boron added, the resulting lead-cemented alloy would be an even more effective shielding material, since boron stops neutrons—also a product of radiation.

The corrosion resistance of lead, plus the increased strength gained by adding other metals, suggests that some alloys might be useful to the chemical industry and other industries requiring corrosion-resistant materials. Other alloys suggest uses for gaskets at temperatures which would burn up plastic gaskets. Bearings for automobiles and rotating shafts are other possibilities.

Lead's softness, sometimes a disadvantage, can be an asset with the new alloys. The lead could serve as a binder for dispersing in mixtures containing less ductile materials like tungsten or materials with properties of special interest, such as very fine iron powder with its unusual magnetic properties.

Novel methods were developed by Battelle for making the unconventional alloys. When large amounts of powdered solids are added to molten lead, the mixture becomes sluggish. A revolving crucible, resembling a cement mixer, was designed to meet this situation. It was found that most metals resist being stirred into molten lead. Special pretreatment of these powdered metals and special mixing techniques were devised. After the hot mixtures were poured into molds for quick hardening, the molds were vibrated to minimize porosity.

The Battelle investigators found that at least six metals are particularly well suited for the new alloys—cobalt, copper, iron, molybdenum, nickel, and tungsten. Experiments show that the size and shape of the metal powder particles, as well as the amount, affect the final material.

"With the feasibility of producing the new alloys now established," the Battelle metallurgists report, "the next step is to develop alloys for special end uses."

Professor Williams to Head IMM

Prof. David Williams, D.Sc., Ph.D., B.Eng., D.I.C., who occupies the University of London Chair of Mining Geology at the Imperial College of Science and Technology, has been elected president of the Institution of Mining and Metallurgy for 1960-61.

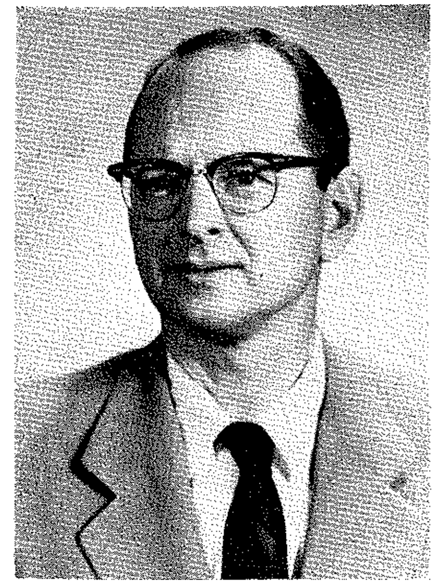
Professor Williams has also given long service to the Geological Society of London and is well known for his many professional publications in pure and applied geology.

He will take office in May 1960, in succession to Dr. J. H. Watson, C.B.E., M.C.

Geochemical Prospecting

By

HAROLD BLOOM



HAROLD BLOOM

Introduction

Although less than a dozen years old in this country, geochemical prospecting methods have found their way into the routine exploration programs of mining companies throughout the world. To be sure, some companies are faring better than others—their success seems to be a function of the willingness of management to provide qualified personnel and adequate supporting funds.

Recently enlightening opinions have been expressed by mining executives regarding geochemical exploration in their companies' programs. Writing in the *Northern Miner* of Nov. 26, 1959, C. J. Sullivan, president of Kennco, Ltd., indicates that about 3.7 per cent of his exploration budget is allocated for that kind of work. He states "Geochemical prospecting, a natural extension of gold panning, offers very great possibilities." Anaconda's vice-president, V. D. Perry, is quoted in the *Wall Street Journal* of May 7, 1959, as saying that his company has increased their geochemical prospecting budget "several fold in the last five years."

Work in the Soviet Union

Scandanavia and the Soviet Union have pioneered in this field since the early 1930's. Dependent upon the expensive spectrograph for trace metal data, geochemical prospecting was largely experimental and remained so until after World War II. The Soviet Union has since emerged with the most extensive program in the world.

Some interesting notes on progress in the Soviet Union are available in a recently translated volume entitled "Geochemical Methods for Prospecting" by I. I. Ginzburg (3). Since 1950, 160,000 square km have been covered with geochemical mapping, showing the distribution of minor and rare metals in the different districts. Between 1954-55, about 10 million samples have been collected; during the previous 20 years, some 25,000,000 sampling sites were examined. Reconnaissance surveys are conducted on a 1:1,000,000 to 1:200,000 scale, prospecting on 1:1,000,000 to 1:25,000 scale and detailed maps for 1:10,000 to 1:2,000. In 1955, by order of the Ministry of Geology and Conservation, geochemists were attached to all geologic agencies engaged in geologic field studies.

THE AUTHOR

A native of Brooklyn, N. Y., Harold Bloom received both undergraduate and graduate training in chemistry at Brooklyn College in 1935. After a brief stint at teaching in New York schools, he joined the U. S. Geological Survey. In 1958, he transferred to the USGS geochemical prospecting program, then in its infancy, and helped organize its analytical laboratory in Denver. His major publications deal with rapid colorimetric methods of analysis and their field applications.

In 1954, he joined the faculty of the Colorado School of Mines as a special lecturer, teaching courses in geochemical exploration. During this time he has rounded out his background in geology.

He has consulted for Selco Exploration Co. Ltd., Dominion Gulf Co. Ltd., Fremont Mining Co., and United Fruit Co., among others. He holds membership in the American Chemical Society, American Institute of Mining and Metallurgical Engineers, Geochemical Society and Colorado Scientific Society.

In contrast to the procedures in this country where geologists with chemical assistance are in charge of geochemical projects, the work in Russia has been carried out by geophysicists. That this is not the best arrangement is noted in the author's appeal for greater integration of geology (and geologists) into the future exploration programs.

The Russians still rely heavily upon spectrographic analysis for chemical data because of the speed and the wide range of elements that can be simultaneously determined. However, in recent years they have been turning more to colorimetric procedures. Spot tests, isotopes, photometric and luminescent procedures all are being investigated for both field and laboratory use.

A large number of ore bodies are listed as having been discovered. Some of these are: In Kazakhstan: Pb, Ag, Cu, Bi, Mo, W; in the Urals: Au, FeS_2, W, Be; in Trans-Baikalia: Pb, Zn, F, W, Mo. In view of the large scale prospecting program that has been going on since the 1930's, it should be no surprise that many ore bodies should have been uncovered. Whether the manpower involved in the program was used as efficiently as one might like, is a matter for speculation.

Work in the United States

The U. S. Geological Survey has played an important role in developing geochemical prospecting in this country and abroad. Their program was directed along two lines: (1) the development of field tests based mostly upon colorimetric techniques and (2) concurrently conducting a research program dealing with the behavior of these elements under varying climatic and geologic conditions.

Many of the field tests developed showed greater sensitivity than the spectrograph, and because they were inexpensive and rapid, they could be carried into the field with little trouble. Persons of all economic levels could easily afford the chemicals needed, and the prospector need not have the extensive training of a spectrographer. Field tests, mostly colorimetric have been developed for the following elements: Ag, As, Bi, Co, Cu, Fe, Pb, Sb, Mn, Hg, Mo, Ni, Se, Sn, W, U, V, and Zn. Dispersion patterns in rock, soil, waters and plants were studied in a series of case histories. Much of this work has been summarized by Hawkes (4).

Other Areas

In 1957, member countries of the British Commonwealth met in Canada to hold their Sixth Commonwealth Mining and Metallurgical Congress. Following this meeting a volume appeared (8) in which geophysical and geochemical exploration case histories are documented. Several of these papers illustrate how more productive exploration can be when geophysics and geochemistry are properly integrated.

What is probably the largest geochemical prospecting effort outside of the Soviet Union is being currently conducted by several private mining companies in Central Africa. In these exploration programs, involving thousands of square miles, more samples are being collected than in all of North America. One company alone is turning out about three-quarters of a million chemical analyses per year, using colorimetric and chromatographic methods. Semi-quantitative spectrographic methods account for about 100,000 determinations per month. This immense amount of work is being turned out at a cost of about 10¢ a sample. The Geochemical Prospecting Research Centre at the Imperial College, London, has been very effective in supporting these efforts. Graduate study leading to the PhD degree is carried out in African field areas.

What Is Geochemical Prospecting?

Geochemists recognize that metals in trace amounts are distributed in an orderly fashion throughout the earth's crust. The abundance of these metals in an area devoid of mineralization is called "background." Thus, the average igneous rock content, in parts per million, of zinc is 132, lead 16 and copper 70. Soils derived from these rocks generally have similar values. When the average background value is exceeded by a factor of two or more, then "anomalous" values begin to become evident. Samples may be selected at any point where metal movement is suspected.

For orientation, let us consider what happens to an ore body when it undergoes weathering. The rock and ore minerals are broken down by physical disintegration and chemical decomposition. Part of this material forms the soil, passes via the root system into the overlying vegetation, while the rest is carried away by surface and groundwaters to the nearby drainage. Sample sites are now readily suggested; the train of metal may be sought in (a) soils, (b) vegetation, (c) stream waters, and (d) stream sediments. But it should be borne in mind that metal anomalies alone cannot be used to indicate either the depth or the grade of mineralization.

Pathfinder Elements

It is common practice to seek the ore metal itself when investigating a dispersion. Occasionally, a better halo is obtained by plotting the accessory elements that accompany the ore metal. These are called "pathfinder" elements.

Zinc is present in most ores of lead, silver and copper and can serve as tracers to these ores. Porphyry copper deposits are associated with considerable though lesser amounts of molybdenum, and the latter is apparently more useful than the copper in seeking these deposits. More recently nickel (6) has been proposed to seek out the diamond bearing kimberlites in the Belgian Congo

Soil Sampling

Recognition of soil types is helpful if one is to guide his sampling intelligently. For example, a podzol soil develops in a temperate climate with average rainfall, and usually undergoes differentiation into several recognizable horizons: An "A" horizon, normally leached to a gray color; a brown "B" horizon where accumulation of iron and aluminum oxides takes place; and a "C" horizon, consisting of disintegrating parent bed rock. Samples collected from the "A" zone would tend to be low in metal; the "B" sample is enriched and uniform in metal distribution while the "C" zone may yield erratic data.

Glaciation presents a special problem because the till overlying the bedrock is transported, and while it may be possible to obtain anomalous metal values at the surface and at depth, the intervening layer may be seemingly barren. Presumably, the metal near the surface has been "pumped up" by vegetation.

Although lateritic soils are the products of extreme leaching, they have been found to yield useful metal data.

Mobility of Oxidized Ore Metals

The mobility of ore metals in the zone of weathering depends principally on the solubilities of their oxidized products. The zinc in sphalerite for example, forms readily soluble sulfates, carbonates and chlorides, and is found far removed from its source. Zinc halos therefore, tend to be broad, lower in metal values and easily distorted by surface waters.

Copper sulfates and chlorides tend to be somewhat more restricted than the zinc minerals, but form similar dispersion anomalies.

Because the oxidation products of galena are mainly insoluble, lead is found to be enriched in the residual soils and forms halos which tend to be sharper and closer to the ore zone.

Vegetation

In a general way, plants will assimilate metal from soils in amounts proportional to that present in the soils. Because of their elaborate root system, they have been found to provide an efficient sample of the metal in the soil, sometimes penetrating as deeply as 60 feet to do this.

Twigs, leaves, stems or roots of certain species have been analyzed and found to yield information successfully used to locate lead, zinc, copper, tin, tungsten, nickel, molybdenum and uranium concentrations.

Some comparisons of the metal content of plant ash from non-mineralized and mineralized areas as shown by Ginzburg (3) are given below:

Element	Non-Mineralized area ppm (1)	Mineralized area ppm (2)	Degree of Accumulation (2 ÷ 1)
Cr	5	100	20
Mn	100	10,000	1000
Co	4	50	12½
Ni	10	100	10
Cu	50	1000	20
Zn	100	10,000	100
Mo	5	100	20
Pb	1	100	100
U	0.01	100	10,000

In this country, the search for uranium in the Colorado Plateau was materially aided by mapping the distribution of the indicator plant commonly known as the "loco weed" (Astragalus pattersoni). Because this perennial thrives in selenium rich soils known to be associated with uranium, their location has often led to ore bodies of uranium. Four ore bodies out of 10 discovered in the Yellow Cat area, Utah, for example, would have been missed but for the additional information furnished by the plant. In the Thompson district of Utah, of 190 holes that were drilled in areas supporting the growth of this plant, 90 were in mineralized ground.

The choice between using plants or soil samples, depends largely on the field problem. However, it is far easier to collect and process soils than plants. The latter need be identified, dried, ground and ashed, usually below 550° C. before analysis is begun, a process which is time consuming.

Stream Waters

Metals may enter the drainage as detrital particles, suspensions, colloids or ions. The distance they travel depends upon a number of factors: as ions, they are dependent upon the pH of the stream waters, which usually run between 6 and 8. When the pH of hydrolysis of a given metal is exceeded, the metal is removed from solution: lead hydrolyzes at 6.0, cupric copper at 5.3, and zinc above 7.0. Despite this laboratory fact, copper and zinc are found in waters whose pH is above their respective hydrolysis points. In a semi-arid area molybdenum sulphide is believed to be first oxidized to a soluble MoO_2SO_4 whereupon it reacts with calcareous rocks to form $CaMoO_4$. The latter is found to be quite insoluble between pH 3 to 9, and yet molybdenum is found widely distributed in waters, soils and plants whose pH environment is about 7 (7). The suggestion that metals may travel as complex inorganic and organic ions, with different chemical properties seems valid.

Changes in water volume, caused by seasonal and daily rainfall may frequently dilute the metal concentration to below the sensitivity of many water tests. Or alternatively, raising the level of the water table, may sometimes result in the flushing out of oxidizing ore metals into the drainage with subsequent high metal readings. The problem of interpretation of metal values in waters may thus become exceedingly difficult.

The accumulation of metals by ground water in areas of mineralization and in areas of background (non-mineralization) are shown in the following table from Ginzburg (3).

Concentration (in Parts Per Billion) of Surface and Underground Drainage

Metal	Background	Mineralized
Ni	1 to 10	10 to 1000
Co	0.1 to 10	10 to 1000
Zn	0.1 to 10	10 to 1000
Cu	1 to 10	10 to 1000
U	0.01 to 10	10 to 1000
Mo	0.1 to 1	100
Pb	0.1 to 1	10 to 1,000

Stream Sediments

Closely allied to water sampling is the use of stream sediments. Metals carried by waters are lost to sediments by coprecipitation, sorption or ion exchange with clays. Once removed, they are found to be loosely held by the sediments and can be removed by cold extraction with acetate, citrate or dilute acid solutions. This has served as the basis for the simple chemical procedures described under "Chemical Procedures" below.

Sediment sampling techniques have certain advantages over water sampling (5): (a) local dilution effects are minimized, (b) dry stream channels may be tested, (c) the chemical procedures are simpler, and (d) samples may be stored for future reference.

Chemical Procedures

Chemical procedures used in geochemical prospecting may be broadly classified on the basis of the completeness of sample solution, into three groups: (A) Solution of primary rock-forming minerals usually silicates, by caustic fusion or by hydrofluoric and perchloric acid attack (complete solution). (B) Solution of relatively insoluble minerals found outside the silicate lattice as metallic sulphides, by hot acids or fusions. (C) Solution of secondary minerals, shose easily soluble and loosely held by cold inorganic acids or organic salts extractions.

The procedures of the first type are generally carried out in a well-equipped chemical laboratory by conventional methods.

The second class of procedures may be used in field laboratories because they are more simplified and rapid than (A) above. A flow diagram showing the outline of the methods used for Zn, Cu, Pb, and Ni by colorimetric procedures is found in *Figure 1*.

In this scheme, a sample may be broken up by either (1:3) nitric acid digestion or by a bisulfate fusion. After dilution to 10 ml, a portion is transferred to a test tube to which a buffer solution is added. The buffer may contain a complexing agent (such as KCN for lead, or $Na_2S_2O^3$ for zinc), or an emulsifier as in the nickel buffer. A colorimetric reagent is then added, and after a short shake a colored product is obtained, the color intensity being proportional to the amount of metal present. By comparison with standard colored solutions, a fair estimate of the amount of metal present is made.

The cold extraction procedures of the third class may be carried out in less than five minutes. This technique easily lends itself to portability in a kit, since the chemical equipment consists of only two polyethylene squeeze bottles, a scoop and a stoppered calibrated test tube. A sample is scooped into a test tube, appropriate amounts of reagents are added from each squeeze bottle and shaken vigorously for five seconds. The amount of metal present is indicated by the intensity of the color in the product. The procedure just described is based upon a cold ammonium citrate buffer extraction (1). One scheme for the determination of copper alone uses acetic acid (2), while another employs an

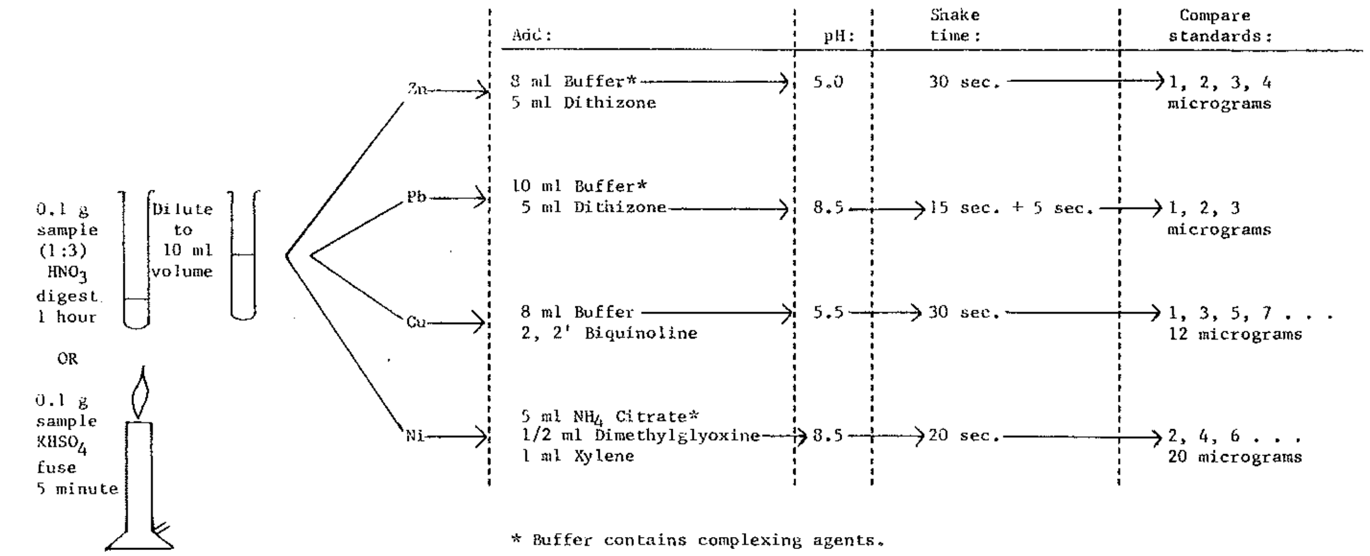


FIGURE 1. FLOW DIAGRAM OF COLORIMETRIC ANALYSIS OF ZINC, LEAD, COPPER AND NICKEL FROM NITRIC ACID DIGESTION OR A POTASSIUM BISULFATE FUSION.

acidified ammonium citration solution (9). While these schemes of analysis are extremely simple, skill in interpretation of the data is essential.

Case History

In a recent issue of the Russian Journal "Geochemistry," (7) several porphyry copper deposits are described as having been discovered by geochemical prospecting in the Kadzharan Mining District of southeastern Armenia, Russia. This survey is carried out in an area underlain with fresh and altered monzonite. Stream waters, soils and plants are all shown to contain high metal values in the area of the ore zones. Molybdenum rather than copper is used as the "pathfinder" because it travels further than copper and appears to be easily assimilated by plant life.

The relative abundance of molybdenum in the earth's crust is about 1.9 ppm in acidic rocks, in podzolic and chestnut soils about 2 ppm, in natural surface waters 0.001 ppm, and 10 ppm in plant ash.

The stream water in the immediate vicinity of the deposits ran from 0.015 to 0.029 ppm and in springs, from 0.31 to 0.4 ppm. Soils and plants contained as much as 1000 ppm.

A soil traverse across the ore zone is shown in *Table 1*. Samples were collected in the "A" horizon at from 0 to 10 cm in depth. The contrast in anomalous values varies from 20 to 68 times background. Molybdenum appears to be held in the humus layer and by clay minerals, minimizing downhill displacement.

Plant studies show that molybdenum is accumulated differently in different plant species, and in different parts of the same plant; most molybdenum is found to be accumulated in the leaves. More molybdenum is found in herbaceous varieties than in trees. *Table 2*, shows the molybdenum content of the ash of different plant species growing in the ore zone at Mts. Yaglu-Zami. The enrichment coefficient ranges from 12 to 50 times background.

Working purely from geochemical data, exploration tunnels driven into the soil anomalies at Mts. Yaglu-

TABLE 1. MOLYBDENUM CONTENT OF CHESTNUT SOILS, COLLECTED IN TRAVSERSE ACROSS ORE BODY, MAIN AREA, KADZHARAN DEPOSIT**

Sample No.	Distance from entrance to Tunnel 34, meters	Mo ppm	*Coefficient of accumulation
130	20, N., downslope	80	26.7
128	At entrance to tunnel	60	20.0
126	20, S., upslope	100	33.3
124	40, S., upslope	100	33.3
122	60, S., upslope	100	33.3
120	80, S., upslope	125	41.2
118	100, S., upslope	167	56.0
116	120, S., upslope	166	56.0
114	140, S., upslope	160	53.0
112	160, S., upslope	100	33.3
110	180, S., upslope	204	68.7
108	200, S., upslope	150	50.0
106	220, S., upslope	125	41.2
104	240, S., upslope	83	27.6
102	260, S., upslope	113	37.6
100	280, S., upslope	102	34.0

*ppm Mo divided by the Mo average in soils (3 ppm)
**After Malyuga (7)

TABLE 2. MOLYBDENUM CONTENT OF PLANT ASH, IN THE ORE ZONE, MT. YAGLU-ZAMI**

Species	Mo ppm	*Coefficient of accumulation
Astragalus aurens	270	27
Stachys annua L.	270	27
Scabiosa micrantha. Desv.	500	27
Scutellaria latifolia L.	200	20
Teuchrium alba L.	150	15
Gypsophila elegans M. V.	200	20
Leontodon sp.	120	12

*ppm Mo divided by the Mo background in plant ash (10 ppm)
**After Malyuga (7)

Zami and Kadzharan during 1955-57, revealed two major copper-molybdenum ore zones. These anomalies are shown in *Figure 2*.

Outlook

A portion of this article has been devoted to the recent progress of the geochemical prospecting program in the Soviet Union because their work, as revealed by recent publications, is truly exciting. While discoveries

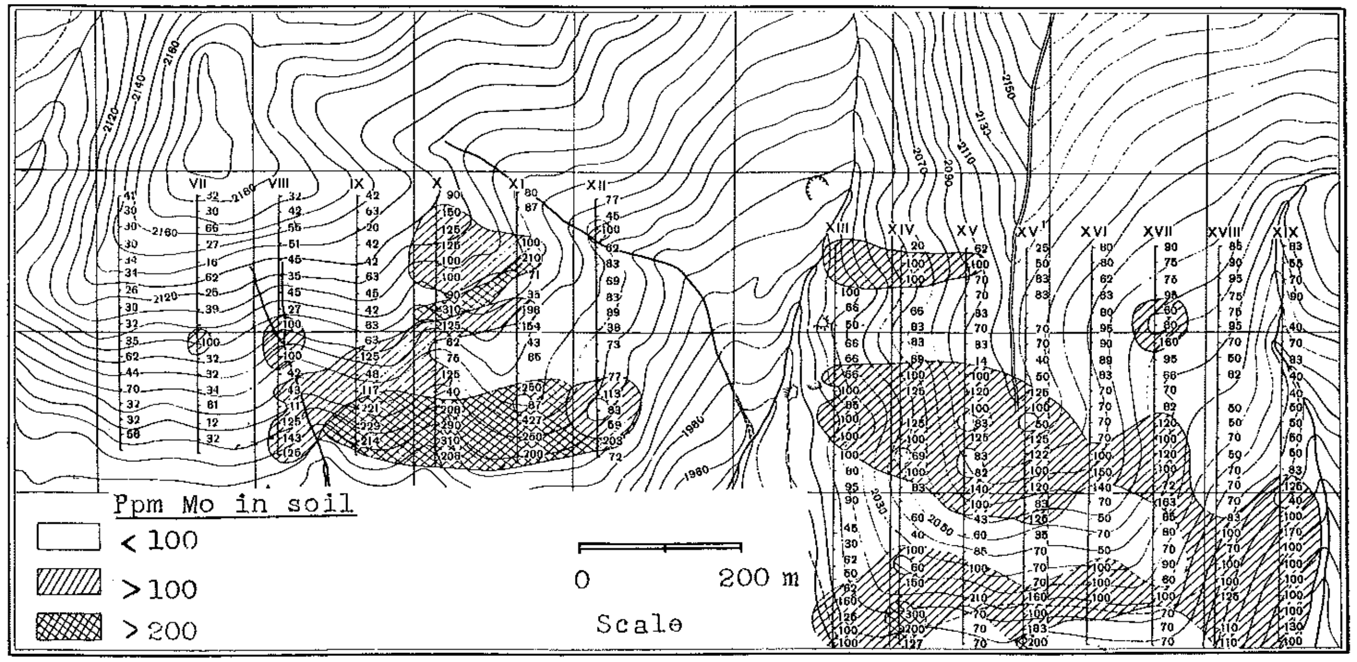


Fig. 2 Molybdenum isograds in soils of left bank of Okhchi River. (After Malyuga)

are many, there is little doubt that this is in part due to the large number of men and material thrown into their program. However, the high caliber of some of their research leaves little doubt as to their ability to go after the deeply buried deposits that we are seeking in our own country. By comparison, the research program in this country is brought sharply into focus—it is behind.

During the past six years, the research programs in geochemical prospecting in the United States have shown only moderate growth. Witness the growth of the Geochemical Exploration Section of the U. S. Geological Survey, the government agency that has been so successful in pioneering the early stages of this field. Only 20 people are engaged in this type of research after 12 years of activity, less than the number attached to any single Russian field party. While a few of the large exploration companies have been carrying out research, their results, because of competition, are generally withheld from the public. Several universities and private research organizations do engage in this type of research, but their dependence upon unreliable outside funds has made for weak programs.

At present, it appears that only through a sustained and increasingly supported program of government research can this country and indeed the Western World hope to remain in the forefront of this vital field.

References

1. Bloom, H., A Field Method for the Determination of Ammonium Citrate-Soluble Heavy Minerals in Soils and Alluvium As a Guide to Mineralization. *Econ. Geol.*, 1955, Vol. 50, pp 533-541.
2. Canney, F. C. and Hawkins, D. B., Cold Acid Extraction of Copper From Soils and Sediments. *Econ. Geol.*, 1958, Vol. 53, pp. 877-886.
3. Ginzburg, I. I., Principles of Geochemical Prospecting. (Translated from Russian by V. P. Sokoloff). *Pergamon Press, Inc.*, New York., 1959.
4. Hawkes, H. E., Principles of Geochemical Prospecting. *U. S. Geological Survey Bulletin*, 1000-F.
5. Hawkes, H. E. and Bloom, H., Heavy Metals in Stream Sediments Used as Exploration Guides. *Mining Engr.*, Nov., 1956.
6. Jedwab, J., Prospection Geochemique de Kimberlite Diamantifere and Congo Belge. *Bull da la Soc. Belge de Geol.*, Tome LXVII, Fascicule 3. 1959.
7. Malyuga, D. P., An Experiment in Biogeochemical Prospecting for Molybdenum in Armenia. *Geochemistry*, 1958, No. 3, p. 314, (A translation from the Russian).
8. Methods and Case Histories in Mining Geophysics. Published by *Canadian Inst. of Mining and Metallurgical Engineering*, Montreal, 1957.
9. Webb, J. S. and Tooms, J. S., Geochemical Drainage Reconnaissance for Copper in Northern Rhodesia. *Trans. Inst. Min. & Met.* Vol. 68, Part 4, 1958-59.

CLASS NOTES

(Continued from page 3)

mailing address Box 35084, Airlawn Station, Dallas 35, Texas.

David R. Cole is project engineer for Idarado Mining Co., Telluride, Colo. His mailing address is 1530 E. Sherwood Dr., Grand Junction, Colo.

N. R. Rowlinson, geologist for United Fruit Co., may be addressed Cia Petrolera de Nueva Granada, Apartado Aereo 3715, Bogota, Colombia.

William D. Watts, staff industrial engineer for Oliver Iron Mining Division, United States Steel Corp., has moved from Hibbing, Minn., to 4316 McCulloch, Duluth, Minn.

1953

Paul Bock left Tsumeb, Southwest Africa, on Jan. 1 and requests that mail be sent to his home address: 10 Stephenson Straat, The Hague, Holland.

George T. Coker has moved from Little Silver, N. J., to Chicago, Ill. with mailing address c/o Shell Oil Co., 624 S. Michigan Ave.

Gene J. Kaefer is now product manager for hydromatic brakes, Brake Division of Parkersburg Rig and Reel Co. at Coffeyville, Kans. Gene had been petroleum engineer with Trunkline Gas Co. at Houston and was the energetic secretary-treasurer of the Houston Alumni Section. His business address is P. O. Box 573, Coffeyville, Kans.

George W. Mitchell, Jr., is a student at the Graduate School of Business, Stanford University, Stanford, Calif.

Franklin A. Seward, Jr., geologist and geophysical engineer for Heinrichs Geoexploration Co., has moved from Lakewood, Colo., to Tucson, Ariz. His P. O. Box number is 5671.

1954

R. J. Andersen, party chief for Geophysical Service Inc., may be addressed

(Continued on page 36)

Carnival in the High Andes*

By

BEN R. HUDSON, '45

One of the difficulties with which many of the Indians living in Bolivia's High Andes have to contend is a chronic shortage of water. Without a steady supply of safe water for drinking and other purposes, they are condemned to a permanently low and precarious standard of living. When the United Nations sent me to Bolivia at the request of the Government, it was to help in locating underground water in the Andes which could become a source of supply for the impoverished Indian residents. This task took me into many unfrequented spots on the Altiplane, and I was fortunate enough to discover water in a number of different places. As a result, a hydrological service is being developed by the Bolivian authorities to survey the country's water resources on a much larger scale. Most of my time on this United Nations assignment has seen me too busy to do anything but concentrate on the job in hand. Day in, day out, there has been more to do than one could find the hours for. It has not, however, been all work.

A Time for Gaiety and Dances

Carnival time in Bolivia, as in other Latin American countries, is a time of gaiety, happiness and festive dances. For nearly a week no one attends much to the routine affairs of life; the carnival spirit is sovereign everywhere. Water fights and folk dances take place in the streets, there are parades and fireworks, and the plazas are vibrant with swarming, colorful, pleasure-seeking crowds. Bands of young people, each with its small dance orchestra, make merry in the streets and homes.

Thus was carnival being celebrated when I was in Cochabamba, Bolivia, the "city of eternal spring." Yet this was a time of sadness for my friend, Hernan Fernandez. Hernan was in mourning for his mother, who had recently lost her life in an airplane crash near Cochabamba, in which 18 other persons, mostly mining engineers from the Oruru district, had also been killed. One day, quite by accident, she had discovered that her isolated and unmanageable farm in the high sierras contained rich veins of lead ore. She had cut her knee on jagged rocks, but the cut was nearly forgotten in the surprising discovery that the protruding rocks were obviously lead ore. This incident led to the opening up of several small, handworked lead mines on the property. After his mother's death, Hernan determined to see if the mines could be made profitable with the use of modern coring equipment and air drills where before only picks, shovels and wheelbarrows had been used.

* This article appears through the courtesy of the United Nations Review which first published it Sept., 1958; Vol. 5, No. 3.

THE AUTHOR

Ben R. Hudson, a 1945 geological engineering graduate of the Colorado School of Mines, is now on his fourth assignment as a hydro-geologist for the United Nations Bureau of Technical Assistance Operations.

With rotary drilling rigs provided by the United Nations, Mr. Hudson set up a ground water organization in Bolivia and is presently doing the same work in Ecuador. Initial stages of the work consist in setting up the rigs, training local personnel in the operation of the drilling equipment, water-finding techniques, and water well-completion methods. After this, engineers and geologists are trained in the more technical aspects of water-data gathering, sampling techniques, map-making, and the organizational matters concerning the efficient operation of a drilling section.

After working for several years as a geologist with major oil companies in the Rocky Mountain area, Mr. Hudson was sent by ARAMCO to Saudi Arabia, where for over three years (1952-55) he was employed in geology, hydrology, and drilling engineering.

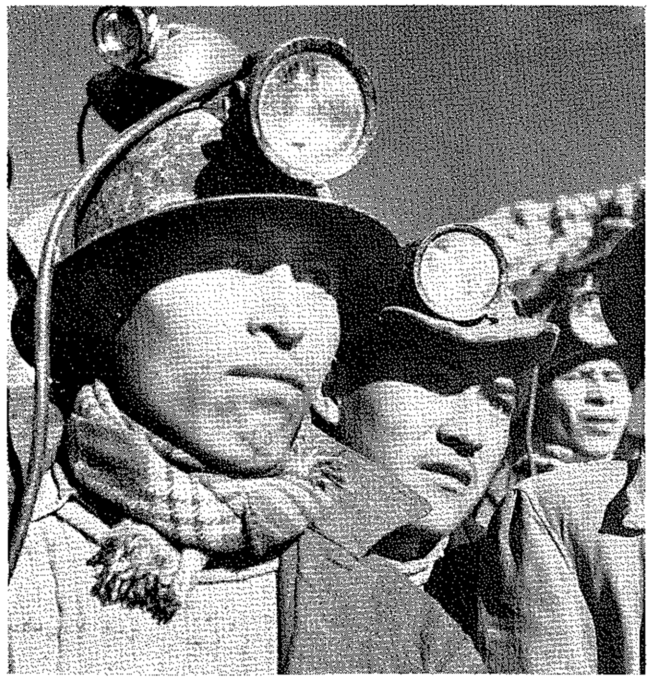
Since his return from the Middle East, he has been with the U.N. on assignments in the under-developed regions of the High Andes.

Invitation to Visit Mines

Hernan had asked me to spend carnival visiting these mines in the remote and inaccessible regions around the town of Independencia, and to make an evaluation of the ore they still contained. The idea appealed to me because I welcomed the chance to see more of the remote parts of the Andes and perhaps something more of Quechua Indian culture in the "high country."

After loading my jeep with a 200-liter drum of extra gasoline, bedrolls, canned food, clothes, pick and shovel, surveying equipment and water jugs, there was barely room for Hernan and me. However, the excess weight gave a smoother ride on the rough mountain roads ahead. As we left Cochabamba at dawn and travelled to the other end of the valley to Quillocolla, before starting the high climb through the Cordillera Real, we passed many ancient trucks jammed with hundreds of Indians being driven to Cochabamba for the carnival festivities.

Our climb was to take us from the 8,600-foot elevation of the Cochabamba Valley to altitudes of nearly 17,000



▾These miners work in the Milluni Mine 15,000 feet high in the Andes mountains. The country is the third largest producer of tin and this metal constitutes 90 per cent of all exports. (Photo courtesy of U.N.)

feet before we reached our goal of Independencia. With our jeep sputtering for lack of oxygen, we eventually came to a point where, looking across the canyon of the Rio Chala, we could see in the distance faint scars on the bare escarpment of the mountain peak. Here the fatal plane had crashed, taking the lives of so many mining engineers, managers, and owners on their tour of Bolivian mining districts. We paused for a moment, but did not try to put our thoughts into words.

In the Dark and the Rain

Night came on and darkness settled rapidly, as is usual in this high and lonely area. Clouds had gathered, and before long the rain came in gusty torrents, tumbling upon us from all sides, rushing down the steep slopes. The road we were now travelling was seldom used; as it wound around the sides of the mountains, it attained elevations of over 16,000 feet, and of all the roads I've travelled in the Andes, this was indeed the most hazardous. About two o'clock in the morning we hit a section which it would have been sheer suicide to try to pass in the dark and the rain. So, in true Bolivian fashion, Hernan in the jeep and me on the ground, we tried to get some sleep. Before light the next morning we were on our way again.

When the sun rose, it revealed mountain scenery such as I had never dreamed of. Snow peak beyond snow peak looked blindingly white in air so pure that the mountains might have been newly made that morning. Yet in this world reaching for the skies there were men and women whose lives were a long struggle with a harsh, unfriendly soil. I was particularly interested to see the Quechua Indians in their own surroundings. They live here in mud huts scattered over the mountains in a random pattern which suggested that they had given no thought to the ruggedness of the terrain. But, of course, this is not a problem to them. These Indians, who do not use the wheel, have no carts, no tractors; they live in simple, but effective, harmony with their natural surroundings. Everything is carried on the backs of women

▾Indian women are employed as laborers at the Milluni mine, located at 15,000 feet altitude in the Andes. Mining is the traditional foundation of Bolivian economy and 90 per cent of the country's exports are unrefined minerals. (Photo courtesy of U.N.)

—or donkeys—and, since time is of secondary importance, no slope is impassable to them. I could see them making brave agricultural use of the most unpromising plots of rock-enclosed land. Slopes too steep for walking or even standing upright were somehow made to grow a little food with the help of oxen and a wooden plow.

I passed many of the Quechua women, dressed in their colorful woolens, spinning as they walked, using a short stick with a hook on one end from which dangles, a foot or two below, a ball or hunk of wool (which may be from the sheep, the alpaca, the vicuna or the llama). The stick is turned with a twist of the fingers, and in this way yarn is spun by the hour as they walk through the mountains or watch the grazing herds of sheep or llamas. The yarn is dyed with natural vegetable dyes and beautiful woolen cloth is woven on crude home-made looms.

Music in a Plaintive Key

Whenever we stopped for a minute I would hear, nearby or far off in the hills, the characteristic music of the mountain Indians, flutes and drums, the flutes carrying the tune in a high, wailing, plaintive key, while the drums keep the rhythmic underbeat.

Later, we heard much more of this music in the villages. Festivals and religion have been practically the only areas in which the Spanish have made inroads into the Quechua culture since the time of the Incas, and even there the Indian has drawn so much of his own into them that the festivals and religious ideas are often unrecognizable to the Catholic Spanish. The dances we saw consisted of simple shuffling steps done to patterns not dissimilar to many western folk dances, accompanied by drums and flutes, with the dancers chanting and wailing in high, child-like voices. Sometimes this music sounds haunting and sad and then in a moment, it becomes lively and contagious in its gaiety.

We did eventually arrive in Independencia about noon the day after our departure, and we sought out the only hotel. Its two rooms were occupied. The old Indian woman led us to a storeroom, which she cleaned out for

us. We spread our blankets and bedrolls on the worn, red-brick floor, as so many other weary travelers had no doubt done before us.

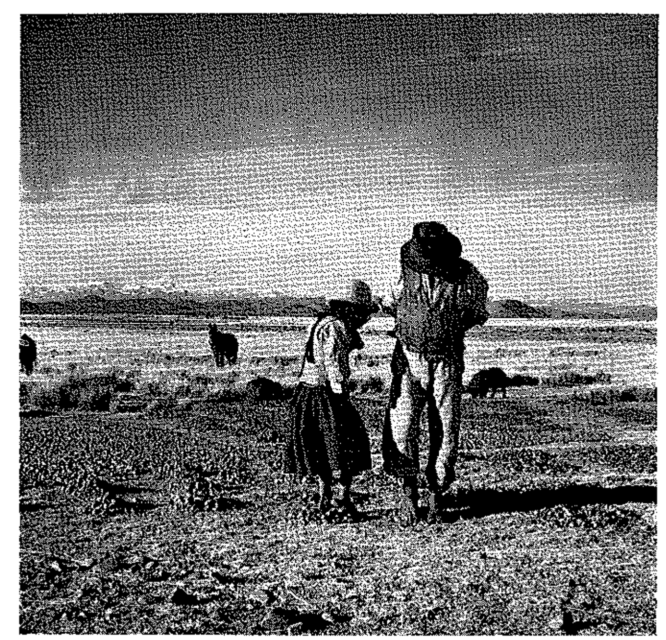
Mapping the Mines

Early next morning, after the usual Bolivian breakfast of black coffee and bread, we started up the rugged mountain trail astride brown and black horses and with two guides hiking alongside. Four more hours of climbing brought us to the old hacienda of Hernan's parents, situated high on a shoulder of mountain with a beautiful, deep green valley below it. The hacienda was in the old Spanish colonial style, surrounded by worn-out orchards and extensive grounds. Tall eucalyptus trees stood like sentinels in front of the main building. A few Indian caretakers were living in mud huts at the back of the patio, baking bread in mud ovens.

Hernan and I visited four or five lead mines within a few miles of the hacienda. We stayed there a few days making a reconnaissance map of the mine holdings. The local Indian tradition demanded that we chew coca leaves and spit the juice into each mine entrance before coming in ourselves.

Indians Chew Coca Leaves

Nearly every adult Indian of the Andes chews the leaf of the plant from which cocaine is extracted. It is true that the coca chewer is often in a state approaching stupor, and it is evident that the brain must be dulled by this habit, yet some students of the Andean Indians are inclined to think that, without the coca leaf, they would not have been able to withstand the long hours of toil they have to endure to exist at all with their primitive implements, nor could they have so well withstood the bitter cold of the upper highlands on their meagre and inadequate diet. For their survival under these awe-inspiring conditions, perhaps some thanks must be given to the coca leaf, their daily friend and companion.



▾Potatoes are one of the food staples and the Indian population has, through necessity, developed their own method of dehydration to preserve part of the harvest for their own consumption. The potatoes are allowed to freeze in the cold night air then all the water is stamped out by the barefooted Indians. Raw, mashed potatoes (Chuno is the local name) are then spread out to dry in the hot sun which shrinks and turns them almost black in color. Here at Cala-Cala one of the farms belonging to the Pillapi group, a father and daughter are shown in the process of making Chuno. (Photo courtesy of U.N.)

Efforts, however, are being made by the authorities to discourage this practice. Government plans to raise the living standards of the Andean Indian by technical assistance and by removing whole communities down to fertile soil at a lower altitude should give these mountain people for the first time for centuries a new aim in life.

We left the hacienda for Independencia late on the third afternoon, hoping that the full moon would light us on our way down the steep mountainside. To our dismay, the skies clouded over, and the darkness in the mountains became so impenetrable that it was impossible to ride our horses any longer. Fortunately, our guides had brought a miner's acetylene lamp and, leading our horses, we picked our way down the rocky trails. Occasionally in this vast solitude we could catch the faint sounds of drum and flute and the curious, plaintive wailing of Indian revelries. Now and again, the outlines of mud huts and moving shadows of people stood out against a background of bonfires. I was beginning to get a "feeling" for the life of these isolated mountain people. The very silence seemed to hint at some elusive secret which, with a little more understanding, I might share.

A Light on the Trail

As we picked our way carefully downhill, we saw a strange, glowing light which appeared to be dancing down the mountain toward us, bobbing up and down among the trees. It seemed to be moving rapidly a few feet above the ground and there was no way of relating it to anything we had seen before. Then there burst upon us a barefooted Quechua woman, running as if for her life with a wide clay bowl full of red-hot coals. How she managed to move so fast on that dark, rocky trail I will never understand. She shouted something to us in the explosive Quechua language and ran on without pause.

Five minutes later, we encountered this woman again beside the trail. Three other women with red-hot coals were crouching beside her. I thought it must be some

(Continued on page 30)

▾This is an Indian market place. The women conduct the trade. Rice is the principal item offered for sale; the consumption of milk, fresh fruit and vegetables is extremely low, not to say non-existent, which helps to explain the extraordinarily high infant mortality rate. (Photo courtesy of U.N.)

Fundamentals of Electrical Concentration of Minerals

By

JAMES E. LAWVER, '43

In principle, the electrical concentration of minerals is quite simple. The operation is merely that of utilizing the forces acting on charged or polarized bodies in an electric field to effect a selective sorting of the mineral species introduced into an external electric field. In actuality, the method of effecting a separation is frequently interestingly difficult due to our lack of knowledge of the relatively new science of solid-state physics that is associated with the problem. In fact, it can be said that the most important recent contributions to the understanding of the "art" of the so-called electrostatic process of concentrating minerals have been the indirect contributions by solid-state physicists among whom may be mentioned Seitz[1], Kittel[2], Mott[3], and Gurney[4].

Much of the notorious confusion and the nonreproducible results involved in "electrostatic"* separations of minerals stem from the inability to isolate all the factors that influence a selective separation. A discussion of some of these factors constitutes the subject of this paper.

In an electrical beneficiation process for solid substances the major electrification mechanisms are:

Contact electrification

Electrification by inductive conduction

Electrification by virtue of mobile ions

Each of the above mechanisms gives rise to a surface charge density on the solid particles. If the charged particles are in a uniform, external electric field they will experience an electric force such that

$$F = QE$$

F = force in newtons

Q = the total charge on the particle in coulombs (1)

E = field strength in $\frac{\text{volts}}{\text{meter}}$

If a separation is made in air (STP) the maximum value of the surface charge density is about 3×10^{-5} coulomb/meter^2 and the maximum value of E is $3 \times 10^6 \frac{\text{volts}}{\text{meter}}$. Thus, a spherical particle of radius

* The term electrostatic process is somewhat a misnomer because the process usually is time dependent. It is generally used by metallurgists to describe any mineral beneficiation process that utilizes an external electric field.

THE AUTHOR

Dr. Lawver attended the Colorado School of Mines, receiving his engineering degree in non-ferrous metallurgy in 1943. He obtained his doctorate at Mines in 1956 in extractive metallurgy. At this time, he also did some work in the fields of mathematical physics and instrumental analysis.

He has also attended numerous courses in specialized fields of mineral processing such as X-ray diffraction, electron diffraction, electron microscopy, and operations research.

His experience record includes that of a mining engineer at the Braden Copper Company in Chile, South America, and with the Bureau of Strategic Warfare in Brazil. He is a registered engineer in the state of Florida where he is currently employed by the International Minerals and Chemical Corporation as a research specialist.

Dr. Lawver holds 26 domestic and foreign patents.

r cm. charged to its maximum surface charge density will experience an electrical force F in a maximum uniform electric field E,

$$F = 4\pi(r \times 10^{-2})^2 \times 26.6 \times 10^{-6} \times 3 \times 10^6$$
$$= \frac{r^2 \text{ newton}}{10}$$
$$= 1 \times 10^4 r^2 \text{ dynes} = .022\, r^2 \text{ pounds}$$

It is interesting to compare the magnitude of the above force to the force of gravity acting on the spherical particle with radius r cm. and a specific gravity s

$$F(\text{gravity}) = \frac{4\pi}{3} r^3 R \times 980$$

which is about 4×10^3 R r^3 dynes

Whence the ratio

$$\frac{F \text{ electrical}}{F \text{ gravity}} = \frac{2.5}{Rr}$$

Thus a fully charged 28 mesh (.0589 cm.) quartz particle could experience a maximum electric force of

$$\frac{2.5}{2.65 \times .0589} = 15.8 \text{ times its weight}$$

In practice the usable maximum electric field is about 80% of theoretical value and the value of the surface charge density is about 5% of the theoretical maximum, thus the above value becomes

$$\frac{F \text{ electrical}}{F \text{ gravity}} = \frac{0.1}{s\, r\, (\text{cm.})} \qquad (4)$$

For completeness it should be noted that in addition to this force, the particles may experience two other forces in a non-uniform electric field, viz., the force due to a permanent dipole having a moment per unit volume of **P**

where $\mathbf{F}_p = \text{grad}\,(\mathbf{P} \cdot \mathbf{E})$; (5)

and the force $\mathbf{F}_d$ that arises from the energy change in the electric field due to the entrance of a solid with a value of relative permittivity different from that of the medium in which the separation is made,

where $\mathbf{F}_d = \frac{1}{2}\, \text{grad}\, [(\mathbf{D}_p - \mathbf{D}_m) \cdot \mathbf{E}]$

$\mathbf{D}_p$ = displacement vector in the particle (6)

$\mathbf{D}_m$ = displacement vector in the medium

These forces are useful in determining the relative permittivity of mineral grains, and have been utilized commercially in fluid separations by Hatfield[5]. They are, however, very small compared to that of Eq. (1) in the type of separations with which we concern ourselves in this paper and will therefore be disregarded.

We will also consider the case in which the image force acting on a charged particle in front of a conducting surface in the absence of an external electric field is the principal electrical force used to effect a separation. The image force $\mathbf{F}_1$ can usually be expressed in terms of Coulomb's law; thus,

$$F = \frac{9 \times 10^9\, QQ_1}{(2R)^2} \text{ in newtons} \qquad (7)$$

where $Q = -Q_1$ = the total surface charge on the mineral in coulombs

and R = the distance from charge to the grounded plate in meters

We shall tacitly assume that inter-particle electric forces can be neglected and that the presence of charged particles in a field does not materially alter the external electric field. Once a particle has obtained a surface charge it is thermodynamically unstable until the charge has been neutralized. In general, the average surface charge on a mineral tends to decrease due to "conduction" or due to "acquisition" of charge of opposite polarity.

All the above mechanisms and the electrical forces are active, to some extent, in every commercial separation of minerals. It is convenient, however, to discuss each of these in sequence.

Charging by Contact Electrification

It is readily observed that when two dissimilar† surfaces are brought into contact, each surface will bear exchange charges at the moment contact is broken. Contact electrification is also known as frictional electrification, the role of rubbing being to increase the area of contact. In charging by particle-particle contact electrification the area of contact is usually quite small, thus it is necessary to provide some mechanical method of causing repeated contacts in order to build up an appreciable average surface charge on the mineral surfaces. Any movement of a granular ore causes repeated particle-particle contact. If the ore is composed of poorly conducting particles the resulting charge density often becomes sufficiently high to use this mechanism as a practical means of electrical concentration. In fact, even if no effort is made to cause repeated particle-particle contact (as in the case of charging by inductive conduction), this mechanism cannot be disregarded. The misleading terms "reversible positive," "reversible negative," and "non reversibility," often found in the literature on electrical concentration of minerals, were coined because of the failure to recognize the importance of contact electrification.

The origin of the electric double layer formed at the phase boundary of substances making contact is completely understood only in isolated cases. Adam[7] has classified these origins into four groups:

a. differences in escape rates of positive and negative particles;

b. selective sorption of particles of one sign at a surface**;

c. surface orientation of molecular dipoles‡;

d. transfer of electrons across a phase boundary due to differences in the electronic energy levels of the solids making contact.

Except at high temperatures, the surface charge due to contact electrification of dry minerals can probably be attributed to the transfer of electrons. An interesting rule of thumb to bear in mind is Coehn's rule[8] which states that "when two dielectric materials are contacted and separated, the material with the higher dielectric constant becomes positively charged." This rule is in accord with the modern theory of solids. Zwikker[9] points out that "the material with the greater number of energy levels will have the higher permittivity and will be more easily polarized so that it will give off electrons to the other contact material."

Coehn's rule has been quantitatively formulated by Beach[10] as

the surface charge density $= 15 \times 10^{-6}\,(e_1 - e_2)$ coulomb/meter^2

Where e_1, e_2 are relative permittivities.

It is important to note that the above equation indicates the surface charge density that could be obtained at the moment contact is broken. If the electrification is made in air (STP), it is impossible to maintain a surface charge density greater than about 26.6×10^{-6} coulomb/meter^2 which is the value of the breakdown strength of air.

If we consider an ionic surface with interatomic spacing of the order of 3.2A, then each ion in a surface could be represented by an area of 10A^2. A surface area of 1 square meter would represent 1×10^{19} ions or 5×10^{18} ions of each sign. Assuming univalent ions, we have 8×10^{-1} coulombs of charge of one sign per square meter. Thus the maximum charge in air (STP) could be obtained by a

† This phenomenon has been observed by P. Henry[6] using similar surfaces.

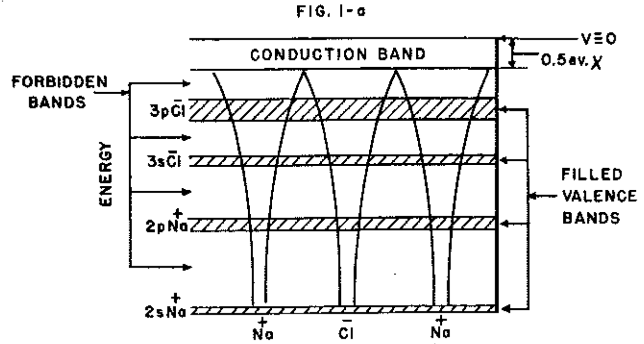
** Interfacial potential differences arising from selective sorption are called adsorption potentials.

‡ Interfacial potential differences due to oriented rows of dipoles are termed lyoelectric potentials.

transfer on only $\frac{26 \times 10^{-6}}{8 \times 10^{-1}} \times 100 = 0.003\%$ of the available ions. A similar result is obtained by calculating possible electron transfer across a metal surface. Although Coehn's rule is reported to have been verified for more than 400 substances, it is of limited value to the metallurgist because of the difficulty in determining the effective relative permittivity of the surface layers (which is often different from the substratum) of two substances that are to make contact. The theory of contact electrification is a very complex subject, and the present theories will inevitably be changed as more exact knowledge is obtained concerning the ionic and electronic properties of solids. No two triboelectrification series are identical; and no extensive literature search is required to find conflicting data of contact electrification tests, even with regard to the sign of the resulting charges.

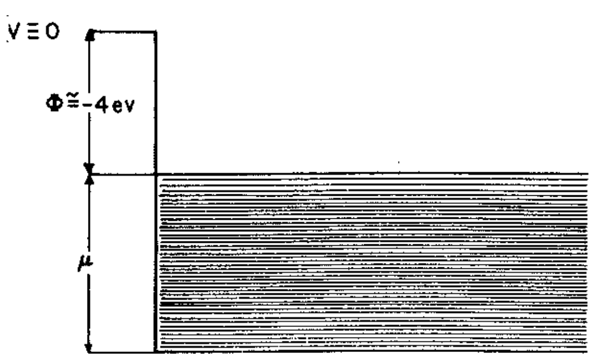
For example, when an insulating crystal such as NaCl or KCl is contacted against a metal at room temperature, there should be no electrons in the conduction band of the insulator so the salt could not become positively charged by losing electrons to the metal. If we take a value of —4ev as the work function of the metal (most metals have a work function near this value) and the value of —0.5ev for the lowest electron energy in the conduction band of NaCl or KCl (Mott and Gurney[11]), we see that the highest occupied electron state in the metal is in an energy state lower than the lowest conduction state in the salt, (see *Fig. 1a* and *1b*) therefore, we would not expect the metal to lose electrons to the insulator (see *Figure 1a*).

FIG. I-a



TYPICAL ENERGY LEVEL DIAGRAM OF A PERFECT INSULATOR

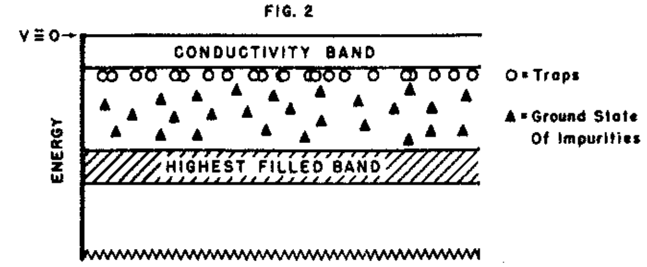
FIG. I-b.



Typical Energy Level Diagram Of A Metal

Yet, real crystals of NaCl or KCl usually will become charged negatively by sliding contact against a metal. Wagner[12] however, reports a positive charge on both NaCl and KCl upon contact with nickel. The negative charge on the insulator is explained by Zwikker[13] as follows: "Electron-containing energy bands of the metal may be in equilibrium with the forbidden bands of the semiconductor or insulator. By wave mechanics, electrons pass from the metal to the boundary and are reflected with exponential return to the metal thus leaving the dielectric negative upon separation." One possible explanation for discrepancies from theory is to assume that part of the surface charge density arising from contact electrification is due to the transfer of ions. In fact it is probable that the total transfer of charge is due to both ions and electrons. Another point of view is to assume that few crystals, and probably no minerals are perfect insulators or perfect intrinsic semiconductors. Leverenz[14] states that "no real crystal ever attains the static perfection of an ideal crystal lattice" and that a real crystal may have distorted surfaces, displaced ions or atoms in interstitial sites and surface sites, and charge displacements due to separated anioncation pairs or abnormal ionized atoms and trapped electrons. Thus the classical energy diagram of a perfect insulator such as NaCl (*Figure 1a*) must be replaced with a more realistic energy diagram (*Figure 2*) which shows the presence of electron or positive hole-trapping states. These traps are capable of acting as donors or acceptors of electrons, and they probably are the controlling influence in the contact electrification of minerals. There are many excellent articles in the literature that explain the origin of electron or positive hole traps.*

FIG. 2



ENERGY DIAGRAM OF A REAL CRYSTAL

The density of these surface states (traps) is approximately the same as the number of surface atoms so that when the unfilled traps are filled by contact with a second solid, the surface charge density may be limited by the breakdown strength of air. It is immediately apparent that the jump at a phase boundary of two contacting minerals cannot be expressed merely as the difference in work functions (as in the case of two clean metals that make contact). It also follows that no two triboelectrification series are apt to be identical since the substances used to form the series may have entirely different electronic properties due to variance in surface states which depend on the previous temperature and chemical history of the minerals. The problem facing the metallurgist interested in controlling contact electrification is that of finding the means of altering, when necessary, the surface of the minerals so that a selective contact electrification can be obtained. The specific treatment depends of course on the particular ore but, in general, the methods involve the creation, or the dumping, of traps† by temperature treatment, or a combination of chemical and temperature treatments.

As an illustration, chemically pure NaCl-KCl mixtures will electrify at low temperatures (150° C) according to Coehn's rule. If a sample of NaCl and a second sample of KCl are heated to about 500° C, cooled back to room temperature and mixed after cooling they will still electrify with a polarity in agreement with Coehn's rule. If, on the other hand, the samples are mixed and then heated to 500° C they will electrify upon cooling with a polarity opposite to that indicated by Coehn's rule. This interesting phenomenon is probably explained in terms of the fact that KCl has a lower lattice energy (168 KCAL per mole) than NaCl (184 KCAL per mole). Upon heating the mixture to an elevated temperature both compounds decompose forming displaced or missing Cl^- ions‡. The density of the stoichiometric abnormality of Cl in the KCl crystals is apparently considerably higher (about 10 to 1) than that in the NaCl crystals. This is indicated by the Cl loss data given in the following table.

TABLE I

Loss of Chlorine from NaCl and KCl by Thermal Decomposition for One Hour at 500° C

Material	% wt. loss as HCl	% wt. loss at Cl_2
C. P. NaCl	3×10^{-4}	2×10^{-4}
C. P. KCl	4×10^{-3}	7×10^{-4}
Sylvite conc. (KCl mineral)	8×10^{-2}	1×10^{-2}
Halite conc. (NaCl mineral)	2×10^{-2}	2×10^{-3}

Kolthoff and Wark in their text "Principles of Flotation" observed that the final traces of adsorbed moisture were removed from halides as the acid rather than moisture.

Presumably the displaced Cl^- ions act as electron traps that are filled by contact with either thermally excited electrons in the conducting band of NaCl, or electrons from donor levels in the NaCl surface, thus giving rise to positively charged NaCl and negatively charged KCl particles, after contact is broken.

In the case of sylvinite ore from Carlsbad, New Mexico, the surfaces of the NaCl and KCl particles are such that either a chemical or thermal treatment must be used before suitable concentration can be made. *Figure 3* illustrates the effect of thermal treatment on the electrical concentration on a Carlsbad ore. *Figure 4* shows the correlation between loss of Chlorine and subsequent electrical concentration as a function of temperature.

Numerous tests also indicate that potash ore separation is very sensitive to the original slime content and that the necessity of the high temperature treatment may be associated with the presence of slimes.

FIG. 3

EFFECT OF HEAT TREATMENT ON ELECTRICAL SEPARATION OF SYLVINITE ORE

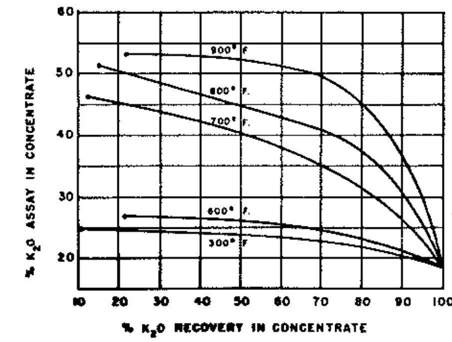
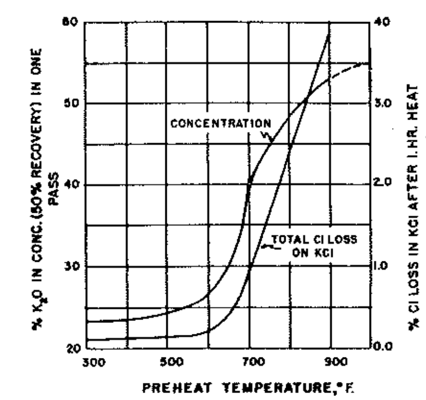


FIG. 4



In some cases it is also possible to alter the surface of one of the mineral species in the ore by selective reagentizing or other chemical treatment using methods similar to those in froth flotation.

In many simple cases it is only necessary to have discrete surfaces in order to obtain suitable particle-particle contact electrification. The treatment is then simplified to that of desliming (removal of a common surface from the mineral species in the ore). For example, Florida quartz contacted against Florida phosphate rock will charge the quartz highly negatively and the phosphate rock equally positively over a temperature range from about —40° C to 300° C. Sea sand contacted against silica gel will cause the quartz to be positively charged and the silica gel negatively charged (at 30° C).

FIG. 5

TYPICAL ELECTRICAL SEPARATION OF FLA. PHOSPHATE ROCK USING PARTICLE-PARTICLE CONTACT ELECTRIFICATION CHARGING MECHANISM

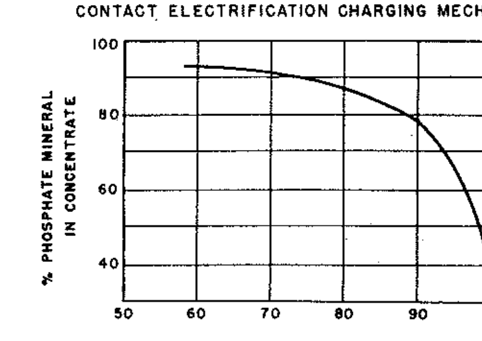


Figure 5 shows the mineral distribution of a single pass for a separation of quartz from Floida phosphate rock at a temperature of 150° C. The

* Bardeen (15), Shockley (16), Mott and Gurney (17), Vick (18), Leverenz (19).

† Loeb[31] points out that local heating is also an important effect in electrification due to ion transfer.

‡ Leverenz[20] ascribes the trapping of X-ray-excited electrons in KCl crystals to sites of missing or displaced Cl ions in the crystals.

mixture was water-washed, dried, and heated in a glass container; after which it was poured into an external electric field of about 4×10^5 volts per meter. There was, of course, some electrification due to mineral-glass contact, but if we consider the relative surface areas involved, the electrification due to the glass can be neglected.

The average surface charge density on $-48+65$ mesh of quartz-Florida phosphate particles was computed by photographing the trajectories of the particles in a known, uniform, external electric field. The maximum charge was of the order of 1×10^{-6} coulomb per square meter. Since the maximum charge in air could be about 26×10^{-6} coulomb per square meter it appears that only approximately 4% of the theoretical charge was obtained by particle-particle contact electrification. The low charging efficiency probably is due to the impossibility of making contact (even with considerable movement to effect repeated contact) because of the roughness and re-entrant angles of the surface involved.

Particle-particle contact can not be assured merely by increasing agitation because one of the operating difficulties associated with particle-particle contact electrification is the prevention of the formation of a common surface on all minerals. A common surface tends to form by virtue of attrition during the material handling stages of the process. This undesirable phenomena places a rather imposing requirement on the design of a commercial flow sheet.

Experimental Techniques

The metallurgists faced with the problem of designing commercial electrical beneficiation processes must first determine the conditions that will lead to optimum selective charging of the minerals in the ore to be concentrated. There are many sophisticated experimental techniques that can be used including the determination of glow curves (Leverenz[21]) optical absorption studies (Mott[22] and Gurney[23]) and X-ray and electron diffraction techniques. A less didactic but more direct approach to the problem is disclosed by using some of the experimental set-up used at the Colorado School of Mines shown in *Figures 6, 7, 8, 9,* and *10.*

▼Fig. 6

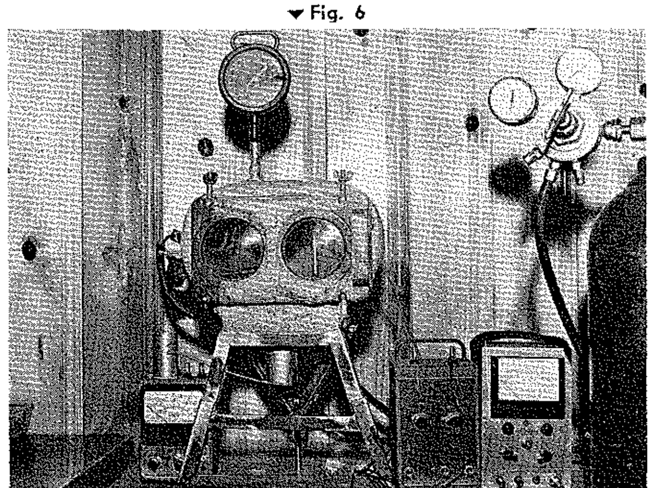
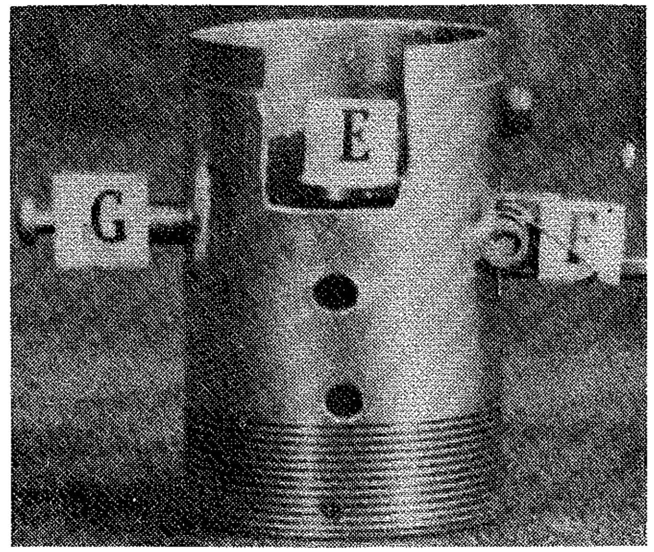


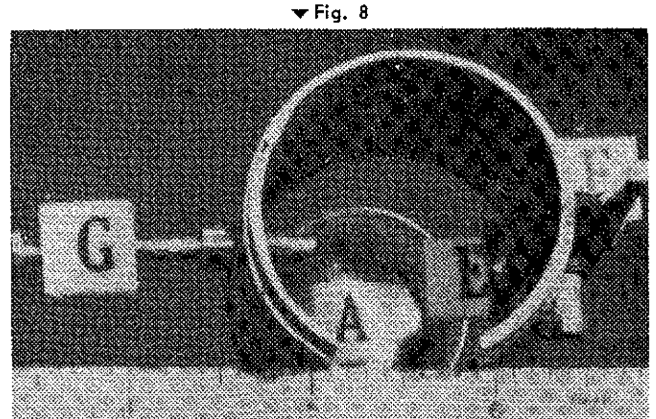
Figure 6 depicts a chamber used for contact electrification tests. The ambient temperature is adjusted through the use of thermostatically controlled strip heaters mounted on the upper part of the chamber. Ambient pressure and chemical composition can be controlled by filling the chamber to the desired pressure from compressed-gas cylinders of known chemical composition. Humidity can be controlled by standard H_2SO_4-H_2O solutions within the chamber.

▼Fig. 7



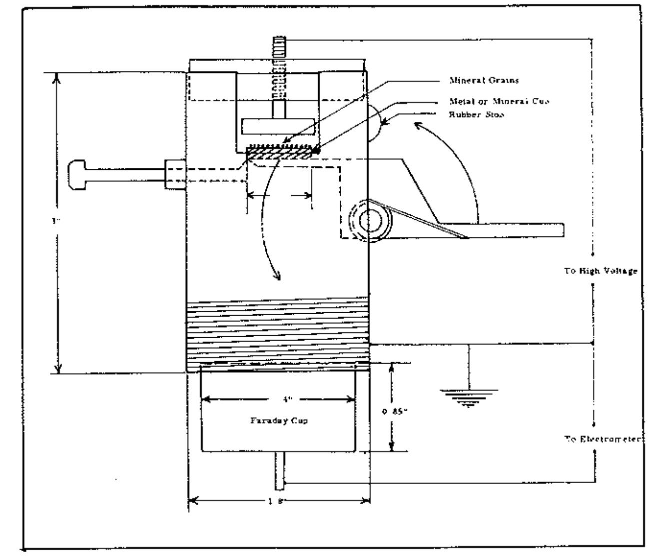
A contact-break-contact apparatus is shown in *Figure 7.* A metal cup E is held in a horizontal position by means of a pin G opposing the motion of a spring F. Contact between a mineral and the metal cup is made by placing the grains in the cup. Exchange-charge is determined by allowing one of the two contacting substances to fall into a Faraday pail, and the resulting potential rise between the pail and the earth is then measured with a vacuum-tube electrometer*. When the pin G is retracted as is shown in *Figure 8,* the cup moves to a vertical position, thus permitting the grains to fall into the Faraday pail A. In the case of contact between two minerals, we merely substitute one of the minerals for the metal cup. A cross-sectional view of the contact-break-contact mechanism including an auxiliary head for studying contact electrification in the presence of an external electric field is shown in *Figure 9.* The central system is shown in *Figure 10.*

▼Fig. 8

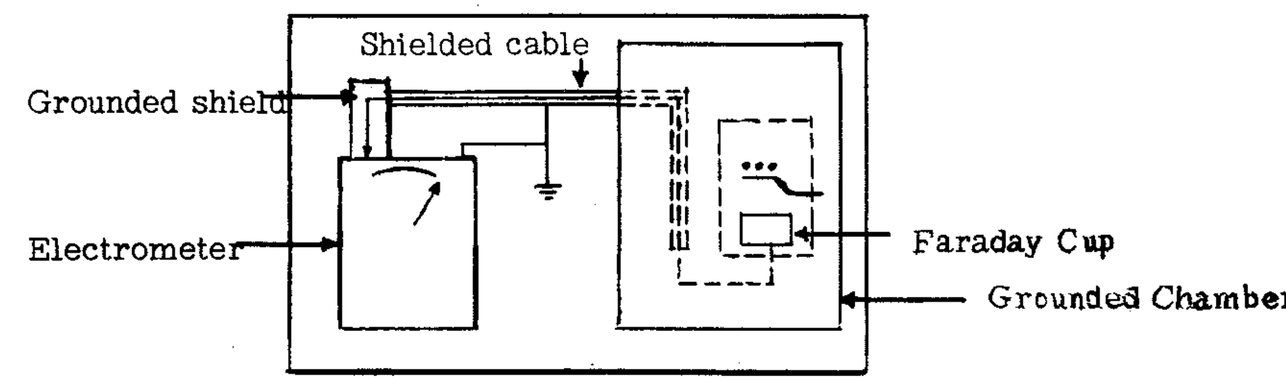


* The electrometer used is a Keithley model 200A vacuum tube electrometer with an input circuit consisting of a resistance greater than 10^{14} ohms shunted by a capacitance of 6 $\mu\mu f$.

▼Fig. 9



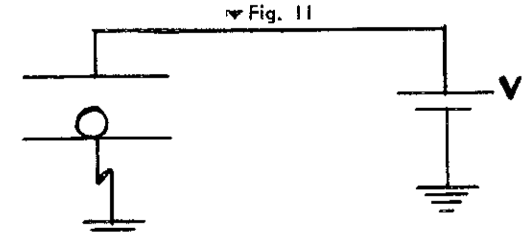
▼Fig. 10



Charging by Conductive Induction

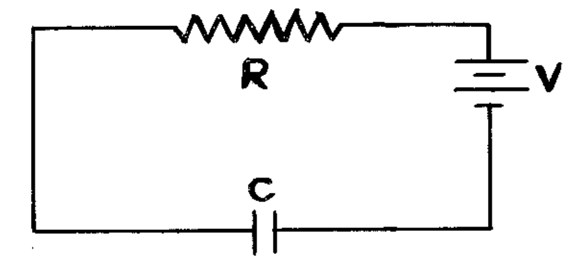
Let us consider a solid particle resting on an earthed conductor in the presence of an electric field as is shown in *Figure 11.*

▼Fig. 11



The particle rapidly develops local surface charges by induction, but, if the external field is uniform and the particle has no initial charge, the particles experience no electric force. If the particle is conductive, it will become charged to the same potential as the metal plate upon which it is resting, with a total charge $Q = C_p V_p$, whence it will experience the electrical force $\mathbf{F} = \mathbf{QE}$; where C_p is the capacitance of the particle and V_p is the potential difference between the metal plate and the charging electrode. If the particle is a dielectric, we cannot, in general, speak of its potential because the potential varies from point to point on the surface of the dielectric. A particle with finite conductivity will eventually obtain a total charge $Q = C_p V_p$, but the time required may be very large. The problem can be approximated if we consider the following as an equivalent circuit:

▼Fig. 12



Let R = the effective particle surface resistance. The value of R will depend on the temperature of the sample, its previous chemical and temperature history and, in many cases, on the polarity used in the concentrating circuit. It may be possible to favorably alter the effective resistance of a mineral by heating the mineral in the presence of the vapor of one of its constituent components to produce a stoichiometric abnormality, or by introducing impurities into the mineral such that it will behave as a semiconductor. It is also possible to alter the effective resistance of a mineral by irradiation with electromagnetic energy of a suitable energy. Under given conditions, however, one can assign an effective value of R and consider that the charging mechanism will behave as follows; neglecting inductance one can write:

$$iR + \frac{Q}{C_p} = V_p$$

$$\text{where } i = \frac{dQ}{dt}$$

$$\text{or } \frac{dQ}{dt} + \frac{Q}{C_p R} = \frac{V_p}{R}$$

If we assume the particle to have an initial charge $Q_o = 0$,

$$\text{then } Q = CV_a - CV_a e^{-\frac{t}{RC}} = CV_a\left(1 - e^{-\frac{t}{RC}}\right) \quad \text{(E-7)}$$

The practical interpretation of the analysis is (a) the charge Q at time t is proportional to the capacitance of the particle and to the potential of the charging electrode, and (b) the time required to charge the particle to a given fraction of its final charge is proportional to the particle capacitance and its resistance. For example, the particle charges to 63% of its final charge, in time t = RC.

Unfortunately, attempts to tabulate the electrical conductivity of minerals are almost hopeless because the conductivity of a mineral, at a given temperature, may vary as much as one thousand fold for specimens taken from different locations. Nevertheless, many minerals can be selectively charged by careful control of charging time, according to Equation E-7. Even if the conductivity of the particles is known and can be controlled, the problem of selectivity making a separation using inductive conduction as a charging mechanism will not be completely solved because, in addition to the surface charge due to inductive conduction, there will be nearly always a surface charge due to (a) particle-particle contact electrification, and (b) particle-metal contact electrification. We note that there is no selectivity of the conductive particles with respect to the sign of the charge they bear when they are charged by this electrification mechanism. This exaggerated example also illustrates the importance of making a particle-particle contact electrification separation at the condition of minimum surface conductivity.

Charging by Mobile Ions

If, by some means or other, a small portion of a solid surface is given a surface charge, the charge tends to eventually spread evenly over the entire surface. If the solid is a good electrical conductor, the redistribution of electric charge is almost instantaneous. If the solid is a good dielectric, for example, dry pure NaCl, KCl, or quartz (at room temperature) the redistribution of the same charge will be very slow; it may take several weeks. By subjecting dielectric materials to an atmosphere of mobile ions, their surface is made temporarily electrically conductive. The following simple laboratory experiment illustrates the principle of using mobile ions to selectively separate a conductive mineral from a dielectric mineral by electrical forces.

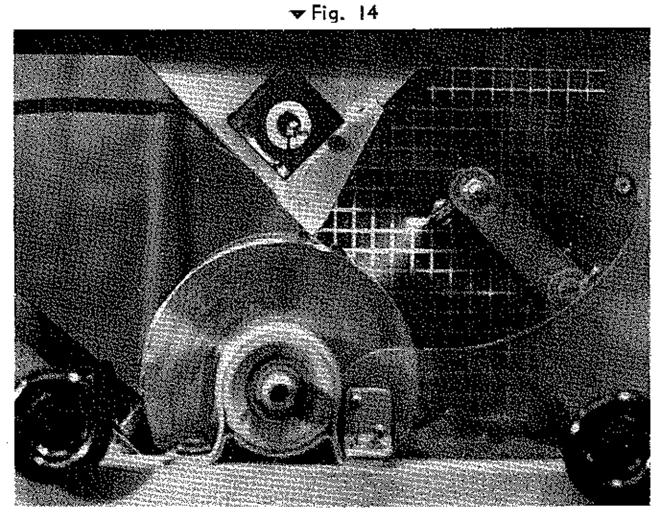
Place a single layer of a mixture of a good insulator and a good conductor (quartz and galena, for example) on a grounded metal plate (see *Figure 13*. Place a second plate with a charge $+Q$ in front of the first. Next, play the flame of a grounded lamp over the surface of the minerals (see Jeans[24]). The entire surface of the minerals on the first plate will then have a total charge of $-Q$ distributed over its surface. (Instead of using "Jeans' lamp" we may, of course, substitute any other convenient ion source.) After the minerals have been charged, remove the plate that held the minerals and invert it. It will be found that the PbS particles, being reasonably conductive, will rapidly share their charge with the earthed plate and will fall from the plate. The quartz particles are not capable of losing their charge and are held to the plate by their own image force. Electrostatic image theory is merely a method of solving Laplace's or Poisson's equations by inspection of symmetry conditions. For a detailed discussion of image theory see any physics text, for example, Sommerfeld[25].

A practical variation of the above experiment is the electrical separation of conductors from insulators using corona discharge as a source of mobile ions. Charging by corona has been studied in detail by Loeb[26], Lowe[27], Lucas[28], and others. The electrification mechanism is due to both ion diffusion, and to ion bombardment. The important factors applicable to electrical concentration of minerals are:

1. The limiting charge Q on a spherical particle of radius r is proportional to the field E, and to the square of the radius. (See Pauthenier[29])
2. If appreciable corona is required, the discharge electrode should be negative because the flash over voltage is higher (Delassale[30]).

The following photograph shows a modern Carpco corona-type separator used at the Colorado School of Mines (*Figure 14*).

▼Fig. 14



This separator has proven quite effective for the separation of electrical conductors from electrical insulators on an industrial scale.* The nonconducting particles are held to the roll by their image forces and are mechanically or electrically removed on the back side of the roll. The mechanical forces utilized in this type of separation are obvious.

Power Requirements

With the exception of the corona-discharge type separator the power requirements for electrical concentration of minerals is (contrary to popular opinion) extremely small. By way of illustration, consider the separation of a ton of -48 $+65$ mesh quartz and phosphate particles in an external field of 4×10^5 newtons/coulomb using free fall electrodes spaced 12.7×10^{-2} meters (5 inches apart). Let us assume that the particles will move half of the distance and that their initial velocity in the direction of the potential gradient is 0. Particle-particle contact electrification will give a ratio of charge to mass of about

$$\frac{Q}{m} = 9 \times 10^{-6} \frac{\text{coulomb}}{\text{Kg.}}$$

The horizontal force $\mathbf{F} = \mathbf{QE}$
thus by Newtonian mechanics

$$QE = \frac{md^2x}{dt^2}$$

where x is the horizontal distance the particle moves during time t

$$\text{thus } \frac{d^2x}{dt^2} = \frac{QE}{m} = 9 \times 10^{-6} \frac{\text{coulomb}}{\text{Kg.}} \times 4 \times 10^5$$

$$\frac{\text{newton}}{\text{coulomb}} = 3.6 \frac{\text{newton}}{\text{Kg.}}$$

$$= 3.6 \frac{\text{meter}}{\text{sec.}^2}$$

$$\text{thus } \frac{dx}{dt} = \text{velocity} = 3.6\,t + C_1$$

$$C_1 = 0$$

$$\text{or } x = 1.8\,t^2 + C_2$$

$$C_2 = 0$$

Hence the total time required for a single particle to traverse 6.35×10^{-2} meters (half the electrode spacing) is 1.87×10^{-1} sec. Whence the final velocity v_f of the particle in the direction of the potential gradient is

$$v_f = 6.7 \times 10^{-1} \frac{\text{meters}}{\text{second}}$$

and the change in the kinetic energy of each particle due to the external electric field is

$$\Delta KE = \frac{m}{2}(v_f^2 - v_o^2) = 4.9 \times 10^{-9}\,\text{kg}\,\frac{\text{meters}^2}{\text{sec.}^2}$$

This energy change has, of course, been obtained at the expense of the external electric circuit; that is to say, each particle requires the expenditure of

$$= 5 \times 10^{-9}\,\text{kg}\,\frac{\text{meters}^2}{\text{sec}^2} = 5 \times 10^{-9} \text{ joules to traverse}$$

the electric field.

The average time t_a required for this expenditure of energy is

$$t_a = \frac{2x}{(v_f - v_o)} = 1.9 \times 10^{-1} \text{ sec.}$$

Thus the power required was

$$\frac{5 \times 10^{-9} \text{ joules}}{1.9 \times 10^{-1} \text{ sec}} = 2.63 \times 10^{-8} \text{ watts.}$$

A ton of -48 $+65$ mesh particles contains

$$\frac{907.8 \text{ kg}}{21.7 \times 10^{-9} \frac{\text{kg}}{\text{particle}}} = 41.8 \times 10^9 \text{ particles.}$$

Thus the power required per ton

$$= 41.8 \times 10^9 \text{ particles} \times \frac{2.63 \times 10^{-8} \text{ watts}}{\text{particle}}$$

$$= 1.10 \text{ kw.}$$

This corresponds to approximately 1 cent-per-ton power cost at an industrial power rate. In other words, the power cost associated with leakage losses, lighting, materials handling, etc., are far greater than the true power requirements for separating a ton of material by the mineral-mineral contact electrification process.

Future of Electrical Concentration of Minerals

The writer feels that the future of electrical concentration of minerals will depend almost entirely on the rate at which our knowledge of solid-state physics and surface physics can be increased. Many combinations of minerals as received from the mine or washing plant can not be selectively electrified by the methods outlined in this paper. It is probable, however, that most combinations of minerals could be made to lend themselves to economical electrical concentration if the metallurgist had sufficient knowledge of solid-state physics. The tremendous strides made by surface and solid-state physicists in the past few years indicate that similar studies by persons interested in minerals beneficiation will lead to tremendous practical accomplishments.

Acknowledgments

The data contained in this paper were obtained from the work done by the writer at the Colorado School of Mines and at the Central Research Laboratory of International Minerals and Chemical Corporation at Skokie, Illinois.

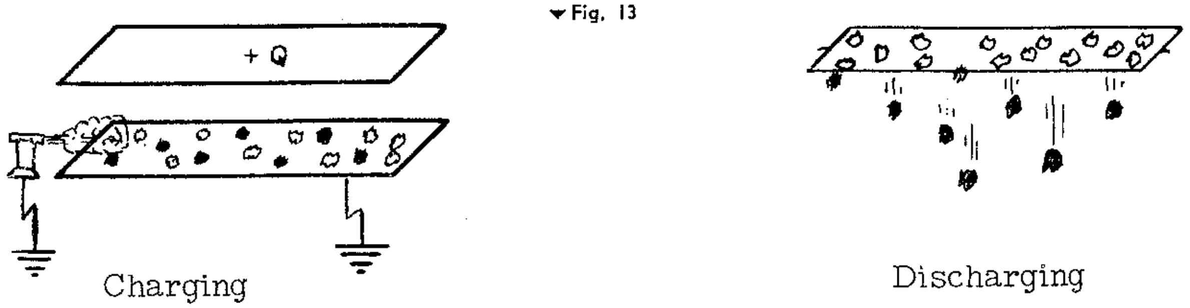
Bibliography

1. Seitz, F., 1940, Modern Theory of Solids, McGraw-Hill Book Co., Inc.
2. Kittel, D., 1953, Introduction to Solid State Physics, Wiley and Sons.
3. and 4. Mott, N. F., and Gurney, R. W., 1946, Electronic Processes in Ionic Crystals.
5. Hatfield, H. S., Inst. of Mining and Metallurgy Bulletin, 1924, vol. 3, Bull. 233, "Dielectric Separation."
6. Henry, P., 1953, Brit. J. of Applied Physics, Supplement to S31.
7. Adam, N. K., 1949, The Physics and Chemistry of Surfaces, Oxford Univ. Press, 3rd edition, p. 300.
8. Coehn, A., 1928, Handb. der Physik, 13, 332.
9. Zwikker, C., 1954, Physical Properties of Solid Materials, Interscience Publishers, Inc., N. Y., p. 253.
10. Beach, R., 1947, Electrical Engineering, vol. 66, p. 325.
11. Mott, N. F., and Gurney, R. W., 1946, Electronic Processes in Ionic Crystals, Chap. 2.
12. Wagner, P. E., Nov. 1956, J. of Applied Physics, vol. 27, no. 11.
13. Zwikker, C., op. cit.
14. Leverenz, H. W., 1950, Luminescence of Solids, Wiley and Sons, p. 47.
15. Bardeen, J., 1947, Phys. Rev., 56, p. 717.
16. Shockley, W., 1939, Phys. Rev., 56, p. 317.
17. Mott, N. F., and Guerney, R. W., op. cit.
18. Vick, F. A., Oct. 1953, Sci. Progr. 41, p. 642.
19. Leverenz, H. W., op. cit.
20. Leverenz, H. W., op. cit.
21. Leverenz, H. W., op. cit.
22. Mott, N. F., op. cit.
23. Gurney, R. W., op. cit.

(*Continued on page 33*)

* The Carpco separator and similar separators such as Sutton, Sutton and Steele, can also be used to charge by inductive conduction or to provide a suitable field for contact electrification separations by replacing the fine wire electrode with a large cylindrical electrode.

▼Fig. 13



Kerr-McGee Mineral Development and Research At Golden

By

V. L. MATTSON, '26

Kerr-McGee Oil Industries is, as the name implies, primarily an oil company. Its basic structure is built around oil and gas production, refinery and gasoline plant operation and a rather unique contract drilling operation which is active in many parts of the world. These operations provide a substantial contribution to our country's "Fuels for the Present." The Kerr-McGee slogan however is "Fuels for the Future," and it is a deep concern for our nation's future sources of energy which has led this oil company into the field of mining and ore processing.

Uranium mining in the Lukachukai Mountains of Arizona and construction of the Shiprock uranium treatment plant represented the first major effort of an oil company to develop raw materials for the development of nuclear power.

Uranium Mill in Ambrosia District

Kermac Nuclear Fuels Corp., which is a Kerr-McGee controlled company, now operates the largest domestic uranium mill in the Ambrosia Lake District of New Mexico. Five major uranium mines are operated as a part of this project. Kerr-McGee owns substantial uranium ore reserves in Wyoming.

Potential energy reserves are represented in the coal properties now held by the company. The fertilizer minerals are in a sense a very real source of energy. Kerr-McGee holds a substantial interest in a potash development in the Carlsbad District of New Mexico. The company has a long range program aimed at development of other minerals which may become important in future energy production.

Pilot Plant, Laboratory Near Golden

The Mineral Development and Research Department of Kerr-McGee is located about five miles northeast of Golden at 5950 McIntyre Road. At this location on a 35-acre tract, the company maintains a pilot plant and laboratory as well as administrative offices for the Department.

The Jefferson County site, which is located in open farm country, is considered nearly ideal for this type of operation. Proximity to Golden was considered as most important. Access to the very fine library of the Colorado School of Mines is valuable to the engineering and scientific staff. Numerous members of Mines faculty have been employed from time to time as consultants on problems in their various fields of mineral industry specialization. Numerous projects which have been conducted at the Colorado School of Mines Research Foundation have been particularly useful because of the proximity of our operations. A number of undergraduate students from Mines have found part time employment during vacation periods and on week ends in the pilot plant and laboratories on McIntyre Road.

THE AUTHOR

Born in Chicago in 1902, V. L. Mattson attended Carnegie Tech in Pittsburgh. He received an E. M. degree in mining engineering from the Colorado School of Mines in 1926.

After graduation he worked for a period in the copper and silver mines of Mazapil Copper Co. in Zacatecas, Mexico. Following this assignment, Mattson was associated with various mining ventures in Canada and the United States for Norrie & Tower with headquarters in New York. He was later chief engineer of Consolidated Feldspar Corp.

Mattson was director of the Colorado School of Mines Research Foundation from 1949 to 1955. Since that time, he has been manager of Mineral Development and Research for Kerr-McGee Oil Industries, Inc.

▾ Kerr-McGee Mineral Dressing Pilot Plant.

There were other factors which we felt made the Golden location almost ideal for this type of facility. The extensive laboratories of the U. S. Geological Survey and the U. S. Bureau of Mines at the Denver Federal Center were only five miles distant. The National Bureau of Standards installation at Boulder and the library and other facilities of the University of Colorado were only 30 minutes from our site. The offices of several prominent designers and builders of mining and metallurgical plants were close by in Denver.

Plant in Operation Since 1957

The pilot plant was placed in operation in the spring of 1957. The first project was to pilot the Ambrosia Lake process. The real value of continuous pilot plant testing prior to design and construction was illustrated in this operation. When pilot plant operations were started, no one had commercially treated any of the Ambrosia Lake ores. Government recommendations indicated that a carbonate leach plant would have to be built even though other considerations favored an acid leach. Solvents which had never been used commercially for extraction of uranium from similar leach solutions had great appeal but not background of performance.

Numerous other features, new to uranium processing, had great possibilities but lacked proof of their ability to perform under operating plant conditions. All of these features after passing careful laboratory tests were incorporated into a miniature mill where they could be further tested under continuous operating conditions that would be duplicated in the full sized plant.

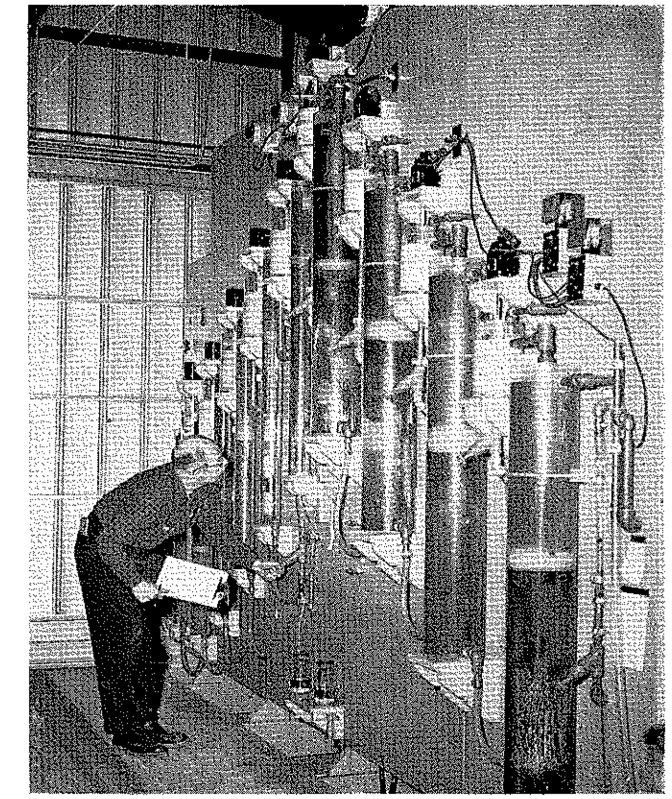
Ore Thoroughly Tested and Treated

The pilot plant operated almost continuously at a rate of 1 ton of ore per day on a 24-hour basis for nearly 18 months. During this period, many variations of process were studied. Ores from every part of the District were treated. When trouble-making impurities were observed in the ores, ways were developed to combat their effects. If troublesome impurities were observed in small amounts, additional quantities were intentionally added so that the effects on the overall process could be observed and corrective measures developed.

The cost and effort involved in the pilot plant studies seemed to be well justified when the $16 million Ambrosia mill started smoothly and reached its rated capacity and recovery after only a few days of operation. The firm knowledge of the process and equipment requirements resulting from the pilot plant operation contributed substantially toward keeping actual construction costs within the estimated limits.

Key Operating Personnel Trained

The pilot plant provided a training ground for most of the key operating personnel in the large plant. Supervisors, foremen, operators and chemists had an opportunity to become thoroughly familiar with the process. They were able to observe through first hand experience the effect of all process variables. Close coordination between the pilot plant organization and the design and construction contractor resulted in the installation of numerous unconventional but highly effective details in the plant.



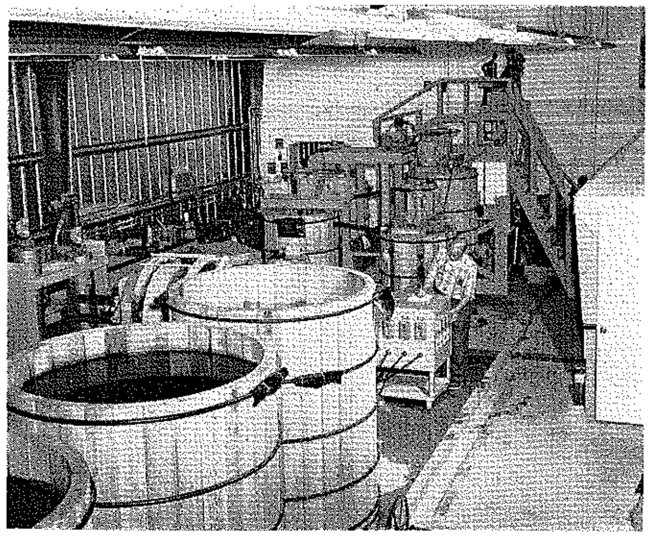
▾ Pilot Plant Solvent Extraction Unit.

A feature of the pilot plant effort was the production of a two volume bound "bible" which has been turned over to the operators of the full scale plant. This book contains all information and data that was developed in the laboratory and pilot plant that relates to the treatment of Ambrosia ores. Microscopic studies of the ores, laboratory bench scale test data, pilot plant detailed operating reports, equipment manufacturers' tests and recommendations, water data, effect of ore impurities, weather and atmospheric observations, everything that may at some time be significant to the operation of the mill has been included in these amply cross-indexed volumes. In this form, the data is available instantly to the mill operators and does not have to be laboriously tracked down through unindexed files or notebooks.

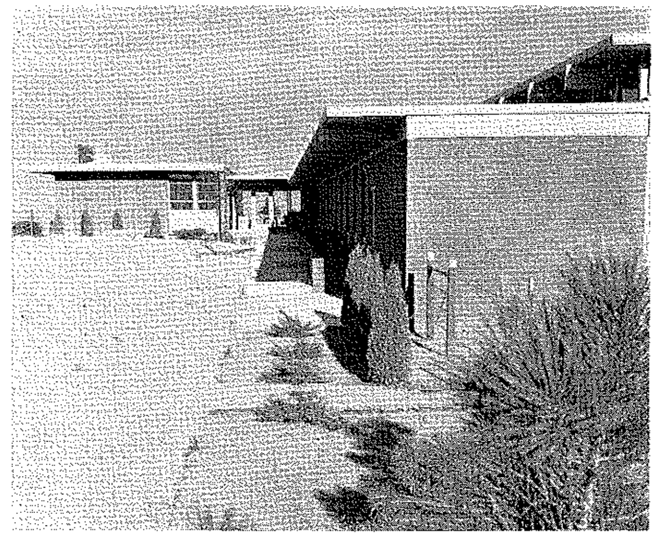
Plant Modified for Other Studies

Since completion of the Ambrosia ore tests, the pilot plant has been extensively modified for other studies. A potash pilot plant has been operated. Tests have been made leading to the development of improved methods for producing uranium tetrafluoride and other compounds required for fuel production. The pilot plant has been so designed that with a minimum of effort and cost, it can be modified to accommodate many types of test procedure.

The Kerr-McGee research laboratory which faces on McIntyre Road is about 200 feet west of the pilot plant. This brick building covers about 8,000 square feet. The building houses various laboratories that are particularily designed for mineral industry problem study.



▾ Pilot Plant Leaching Section.



▾ Mineral Development and Research Laboratory.

Research Staff Versatile

The research staff is composed of specialists in the field of chemical and metallurgical research and development. The research group is small enough and versatile enough so that it is not necessary for the individuals to work within closely defined limits. The rate at which the fields of chemistry, physics, and metallurgy are overlapping frequently makes it difficult to decide whether a chemist, metallurgist, or physicist should be assigned to a problem. It is usual for the solution of a problem at this laboratory to represent the joint effort of the entire group.

Staff Size Varies with Project

The size of the laboratory and pilot plant staff varies considerably with the particular projects which are active. When the pilot plant is running on a three-shift basis, there is normally a two-man crew on each of the night shifts. The day shift will vary from four to six depending upon the nature of the changes being effected.

Laboratory personnel requirements increase rapidly as pilot plant activity increases. Fortunately as a project reaches the pilot plant stage, it is farily certain to develop into a commercial operation. When this is the case, the expanded staff can be made up largely of operating personnel who will move into the commercial plant when it is built.

The Kerr-McGee approach to a mineral development and research effort provides close and continuous service to operations from the research group. Responsibility for not only process development but plant design and performance as well, tends to bring together both scientific, engineering and practical operating skills. Application of countless new scientific and engineering ideas and discoveries to the endless problems of the mineral industry provides a continuing challenge to each member of the staff.

CARNIVAL IN THE HIGH ANDES

(Continued from page 19)

kind of ritual in connection with carnival festivities, and we stopped to watch what was going on. Then, in the glow of the embers, I noticed the tenseness of their bronze faces. They were holding the inert form of a man, a young, strong-featured Indian. Although he was apparently alive, he seemed to be unconscious.

The women raised him partially and made a small canopy over his head with a heavy woolen blanket. Under this and close to his face, they were passing the hot embers with their acrid, poisonous fumes, and some holy incense. He did not respond to these efforts to revive him, and I was shocked at the sight of this helpless man being asphyxiated by the ignorance of three well-intentioned women.

Hernan told them they would kill the man if they persisted. He checked the sick man's pulse and told the women the best thing for him was rest and fresh air. Fumes from the glowing embers would assuredly soon kill him. The women seemed to understand and consented to discontinue their "treatment," so we went on down the trail. Looking over our shoulders, we saw that they had only waited for our backs to be turned. Once more crowded around the sick man, they had started the asphyxiation process again in their frenzied attempts to rouse him.

Bridging Alien Cultures

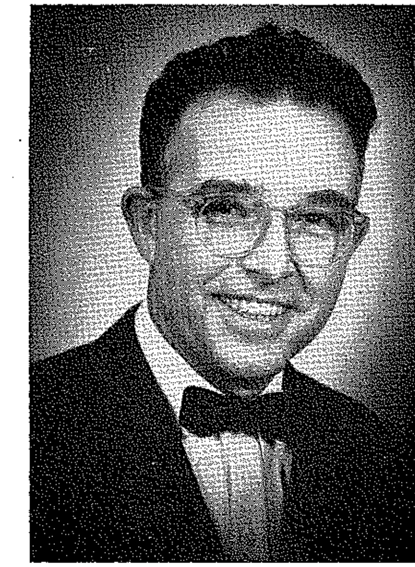
This incident disturbed my previous feeling that I had come close to the Indians and their strange way of life. I could not but reflect how alien one culture can be to another and how difficult it is to make any effective and permanent bridge between the two. This young man's probable death to me seemed a terrible waste due to ignorance. Yet, I was not looking at it from the viewpoint of the Quechua Indians, to whom it would be a tragic event indeed, yet one which in their eyes could not have been avoided. And could they not, perhaps, have laid a similar judgment upon Hernan for allowing his mother to travel in an airplane that brought her and 18 others to their violent death in these very mountains? I was glad when we finally reached Independencia and I could dismiss from my mind these dismal thoughts brought on by the mystery and silence of the high mountain trails.

My memory of carnival time in the High Andes is thus something compounded of very bright and very sombre colors. I remember wild music, dancing, bonfires, and—unexpected, sudden, ominous—the menace of death. Overlooking this tragi-comedy, generation after generation, tower the silent snow peaks. One has the impression that they are brooding over the frailty of human life. If they have reached any conclusions, they keep the secret to themselves.

Explosive Working Of Metals

By

DR. JOHN S. RINEHART



DR. JOHN S. RINEHART

The working of metals: compaction, forming, drawing, swedging, is a new technology which is beginning to contribute significantly to metal working practices and is assuming an important place in equipment ancillary to mine development and production. The recent introduction of the working of metals using explosive charges as a source of power has given rise to fabulous claims, and it has been difficult for management and engineers alike to assess the true worth of this development and the impact that it will have upon metal fabrication processes.

New Method Seems to Violate Rules

Statements appearing in the press are enough to excite even the most conservative: this new method, forming by use of explosive charges, seems to violate all the rules for forming; the tougher the metal the better the results; under such loads even the toughest metals behave strangely, acting more like fluids or plastics than solids. What, then, are some of the facts?

In any explosive metal forming process, one is dealing with explosives, metals, and the nature of the coupling between the two. The source of energy is an explosive, an explosive being a substance or a mixture of substances which on the application of heat, pressure, or a mechanical blow can be converted into gases at high temperature and high pressure, hence capable of doing work. Modern high explosives are, however, very stable, being detonated only under well definable and readily controllable conditions.

Two Main Types of Explosives

There are two main types of explosives: high explosives, characterized by very high rates of reaction, detonation, and high pressure; and deflagrating explosives or propellants, which burn more slowly and develop much lower pressures. The energy released on reaction is usually about 1,000 calories per gram of explosive whether the explosive detonates or burns, but the rate of release of energy in the case of the detonating explosive is very rapid as compared with the deflagrating explosive. In the case of high explosives, the pressure is exceedingly high in the immediate area of the explosive, as high as 4,000,000 lb./sq. in. at the surface of the explosive. A short distance from the explosive, the pressure is much less but its duration much longer.

Propellants, when burned in the open, produce pressures no higher than a burning kitchen match. When confined, propellants can build up quite high pressures, which can be easily controlled, as in a gun, being usually limited to 40,000 to 50,000 lb./sq. in.

THE AUTHOR

In 1958 Dr. John S. Rinehart became professor of mining engineering and director of the mining research laboratory at the Colorado School of Mines, where he is developing a center for graduate study and research in the field of rock physics and the dynamics of explosion, fragmentation and impact, as applied to the mineral industry.

Born Feb. 8, 1915 in Kirksville, Mo., he graduated with a B. S. degree in education and an A. B. degree in physics from Northeast Missouri State Teachers College in 1933 and 1934. He received his M. S. degree in physics from California Institute of Technology in 1937 and his Ph. D. degree in physics from State University of Iowa in 1940.

During World War II he was executive secretary of Division 4 of the National Defense Research Committee which developed the radio proximity fuse for use on rockets and bombs. In recognition for his war work, he was granted the Presidential Certificate of Merit.

After the war, Dr. Rinehart joined the faculty of New Mexico School of Mines, later becoming a research scientist at the U. S. Naval Ordnance Test Station, During 1954 and 1955, he studied and did research at Cambridge University in England. In July 1955 he was made assistant director of Smithsonian Astrophysical Observatory and became a research associate in astronomy at Harvard University.

The author of some 50 papers in physics and engineering journals, Dr. Rinehart also co-authored a book entitled BEHAVIOR OF METALS UNDER IMPULSIVE LOADS. *He is a member of the American Physical Society, American Association of Physics Teachers, American Association for the Advancement ofSc ience, Sigma Xi, Meteoritical Society, American Astronomical Society, and American Society for Metals.*

Sudden Release of Energy

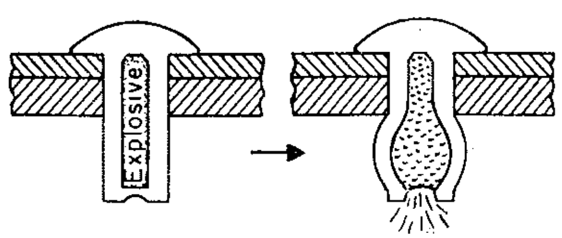
The sudden release of the energy of a high explosion takes place in a microsecond or so, the pressure building up in the same time; the explosion gases rapidly expand, dissipating energy, and the pressure drops suddenly, coming to zero in a few microseconds. The pressure generated by burning propellants takes several milliseconds to develop, but being confined will be sustained for quite long times, decrease in pressure coming about through cooling of the gaseous explosion products.

The diverse applications of explosives to metal forming group into those situations in which the explosive is detonated in intimate contact with the metal to be reworked or formed such as in the hardening of steels, the compaction of metal powders, the splitting of ingots, and cutting operations; and those in which objects such as cups, rocket nozzles, missile noses, and aircraft parts are sized or formed by drawing, using propellants or explosives detonated in air or in water at some distance from the worked piece.

When the explosive is placed in intimate contact with a metal and detonated, the stresses just inside the metal will instantaneously become exceedingly high, and a transient stress disturbance is set up which is transmitted through the metal, producing fracture, plastic flow, and other deformations, the exact nature of which will be strongly dependent upon the configuration of the metal-explosive system. Even under these extreme pressure conditions, the metal is seldom converted to a fluid, exhibiting in general the properties of a quasi-elastic brittle material.

Stratagem in Metal Forming

The stratagem in metal forming is to turn to advantage specific patterns of failures. Thus, ingots may be split by simultaneously detonating explosive charges on opposite sides of the ingot; or the strongly adhering internal scales on heating pipes may be removed by detonating an explosive charge on the exterior surface of the tube, thus dislodging the scale by the same mechanism which causes a picture to be knocked from a wall by pounding on the reverse side of the wall. Explosive filled rivets have been used for many years. (See *Figure 1*).

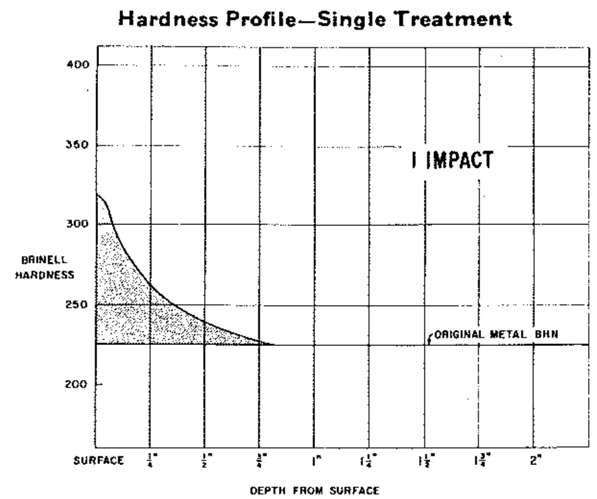


▾Fig. 1. Explosive rivet as it looks before (left) and after (right) setting into metal.

The stress, being intense, work hardens the metal, in some cases to a depth of an inch or more, (See *Figure 2*). Manganese or Hadfield steel, used extensively in mining equipment and notorious both for its resistance to abrasion and work hardening, is now being successfully work hardened by the detonation of thin layers of sheet explosive placed on the surface, thereby greatly increasing its abrasive resistance.

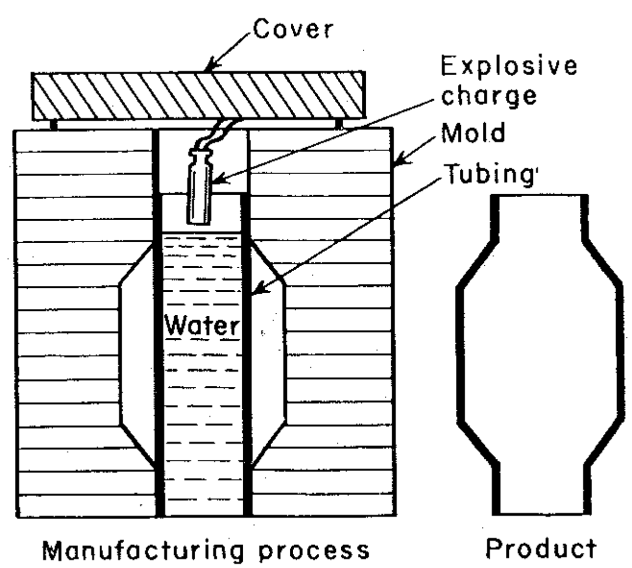
Explosive Separated from Work-Piece

Generally, in explosive forming the explosive is not placed in intimate contact with the metal but is separated from the work-piece by water or some other fluid, as illustrated in *Figure 3*.



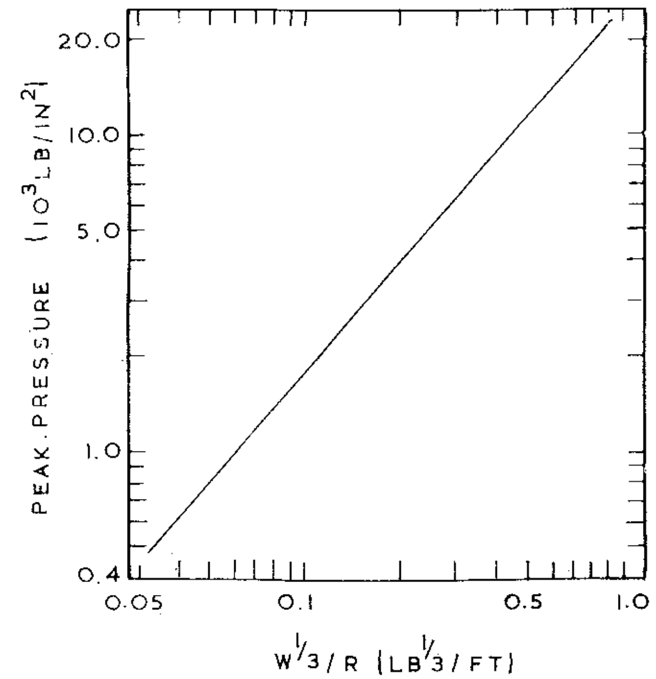
▾Fig. 2. Hardness versus depth profile is shown for a possible explosive impact hardening treatment now being used for manganese steel.

If the intervening medium is air, the peak pressure will be greatly reduced even though the distance between explosive and metal is quite small. A liquid such as water provides a much better coupling medium between explosive and metal than does air. Water, or any other liquid, has the effect of rounding off the pressure pulse. It reduces the peak pressure, while prolonging the time over which the pressure acts.



▾Fig. 3. Monel fan hub is made by hydraulic fluid forming.

Several parameters must be considered in analyzing the action of the pressure pulse upon the work-piece. It is not entirely clear whether it is peak pressure, total impulse, or kinetic energy that is the most important physical parameter needed to describe the interaction between coupling medium and work-piece. Both peak pressure and total impulse are dependent upon the weight of the charge and its distance from the work-piece, both pressure and impulse changing rather slowly with charge weight, specifically, as its cube root.



▾Fig. 4. Peak pressure produced in water by spherical TNT charges is plotted against (charge weight) M/(distance).

Peak Pressure and Charge Weight

Peak pressure and impulse are more sensitive to distance than charge weight, varying inversely with it as the first power. At equal distances away from an 8-lb. charge and a 2-lb. charge, the peak pressure produced by the 8-lb. charge will be only twice that produced by the 2-lb. charge, indicating that in explosive forming operations the size of the charge will not be particularly critical. In *Figure 4*, peak pressure produced in water by shperical TNT charges is plotted against (charge weight) ⅓/(distance). Curves for other explosives such as PETN and blasting gelatin will not be substantially different.

In conventional metal forming, the metal of the part that is to be formed must, at some time during the forming operation, be in contact with the forming die. The distribution of stress established by the die is exceedingly complex, almost impossible to describe, with many opportunities for the development of regions of high stress concentration which, in turn, can lead to fracturing in localized areas. A dynamic stress field of the kind set up when an explosive is detonated in a liquid usually distributes itself more uniformly over the whole piece to be formed, penetrating into every crack, crevice, and corner so that the metal is pushed about uniformly. In effect, it is almost as if one were using a well lubricated die of ever-changing shape, the shape continuously and instantaneously conforming to the shape of the metal part as it is being formed.

Typical Explosive Forming Operation

A typical explosive forming operation such as the sizing of a metal nose cone, 5 feet to 6 feet in diameter, one inch thick piece might be carried out as follows: The partially formed nose cone, dimensionally within several thousands of final tolerance, is placed in a large female die. The cone is then filled with water and one or more small explosive charges, perhaps an ounce each, are suspended in the water at appropriate locations, the charges then being detonated electrically from afar. The charges explode, pushing the water ahead of them against the metal, the metal drawing itself out so as to fill the die completely.

In other cases, water is placed in a polyethylene bag, with female dies sometimes being used, but in other instances the metal being allowed to form itself freely, taking whatever shape the pressure of the pulse dictates. The movement of the metal is not particularly rapid, being at most 100 to 200 ft/sec, a velocity below the critical impact velocity of most metals.

When propellants are used, the system must be gas tight, for the pressure must be allowed to build up relatively slow. A typical operation could be the converting of a thin-walled round tube into one of square cross section. The tube would be placed in a heavy-walled container of square cross section suitably equipped with some means, such as a primed shot gun shell, for igniting a small amount of propellant powder. On ignition, pressure builds up, pushing the round tube outward so as to come up snugly against the square interior of the die.

Less Ductility When Deformed Rapidly

In spite of much propaganda to the contrary, metals as a rule have less ductility when deformed rapidly than when deformed slowly, just as tar will stretch to great lengths when pulled slowly but will break in a brittle manner when struck a sharp blow. A few metals, notably the high manganese and high nickel steels and certain aluminum alloys, show as much ductility at high rates of strain as at low. Copper and certain other nickel steel alloys manifest increased ductility when strained rapidly.

There is a paucity of data on the effect of rate of straining on the ductility of metals, but the physical properties of metals at low temperatures have been extensively investigated and many analogies can be drawn, both behavior patterns being dependent upon activation energies in much the same way. In none of these applications is the metal subjected to such pressures that it is converted to a fluid.

Process in Its Infancy

Metal forming using explosive charges is in its infancy. Its potential is now being evaluated with great intensity of effort in government, industrial and academic scientific communities. It is still too early to make a realistic appraisal of the engineering potentialities of these new and scientifically fascinating modes of processing metals.

ELECTRICAL CONCENTRATION—LAWVER

(Continued from page 27)

24. Jeans, Sir James, 1933, The Mathematical Theory of Electricity and Magnetism, London, Cambridge Univ. Press.
25. Sommerfeld, A., 1952, Electrodynamics, Academic Press Inc.
26. Loeb, L. B., 1939, Fundamental Processes of Electrical Discharge in Gases, Wiley and Sons.
27. and 28. Lowe, H. J., and Lucas, D. H., 1953, Brit. J. of Applied Physics, Supplement No. 2, S46.
29. Pauthenier, M. M., May 1939, Rev. Gen. Elect. 65, p. 583-95.
30. Delassale, A., July 1, 1939, Rev. Gen. Elect. p. 851.
31. Loeb, L. B., Static Electrification, p. 198, 1958, Springer-Verlag-Berlin.

ALUMNI BUSINESS

Officers of Alumni Association
1959

FRANK E. BRIBER, '16
President

WALTER E. REDMOND, '40
Vice-President

KEN W. NICKERSON, JR., '48
Secretary

ROBERT H. WATERMAN, '28
Treasurer

GEO. H. ROLL, '19
Assistant Treasurer

HARVEY MATHEWS, '13
Executive Committee

ROBERT W. EVANS, '36
Executive Committee

FRANK GEIB, '40
Executive Committee

GEO. H. ROLL, '19
Executive Manager

* * *

COMMITTEE CHAIRMEN

K. C. FORCADE, '36
Publications

ROBERT H. WATERMAN, '28
Budget and Finance

NEWELL H. ORR, '54
Membership

RON F. LESTINA, '50
Athletics

R. P. DAVISON, '43
Research and Investigation

E. S. HANLEY, '34
Alumni Endowment

E. H. CRABTREE, JR., '27
Instruction

W. C. PROSSER, Ex-'07
Public Relations

A. W. CULLEN, '36
Nominations

Directors of CSM Foundation, Inc.
Elected by Alumni Association

KEPPEL BRIERLY, '34
MALCOLM COLLIER, '22

* * *

MEETINGS

Executive Committee Meetings
Thursday after 3rd Wednesday each month, Alumni Office, 7:30 P. M.

Meetings of Committees at call of the chairman.

Executive Committee Meeting Of Mines Alumni Assn. Nov. 18

The regular meeting of the Colorado School of Mines Alumni Association was held Wednesday, Nov. 18, in the office of The Stearns-Roger Manufacturing Co., Denver, Colo.

The meeting was called to order at 7:30 p.m. by President Frank E. Briber.

Members present were: Frank E. Briber, president; Walter Redmond, vice president; R. H. Waterman, treasurer; Harvey Mathews, Executive Committee; R. W. Evans, Executive Committee; George H. Roll, executive manager.

Members absent were: Ken Nickerson, secretary, and Frank Geib, Executive Committee.

Committee chairmen present were: E. H. Crabtree, Jr., Instruction; Warren Prosser, Public Relations; A. W. Cullen, Nominations.

Committee chairmen absent were: R. P. Davison, Research and Investigation; E. S. Hanley, Endowment; K. C. Forcade, Publications.

The minutes of the regular meeting of Oct. 15, were read and approved as read.

The minutes of the special meeting of Oct. 21, were read. Moved by Mr. Crabtree the minutes be approved. Seconded by Mr. Cullen. Passed.

Mr. Roll presented the financial statement for the first ten months of 1959. The Association shows a slight loss for the month of October, 1959 but showed a profit of $957.94 for the first ten months period. A better financial picture will be available at the end of November, after the income and expense for the Annual Petroleum issue have been tabulated.

In the past, there has been a misunderstanding about life memberships and the magazine subscriptions. A letter sent to all life members who had paid the fee prior to 1942, was presented pointing out that the life membership previous to 1942 did not include a subscription to the magazine. A card for a magazine subscription was included with the letter. Life memberships paid in 1942 and later include the magazine. This should clarify the situation concerning life memberships and magazine subscriptions.

An application for associate membership in the Association for Joe E. Hopkins was presented. Moved by Mr. Mathews the membership be granted. Seconded by Mr. Crabtree. Passed.

A report from the Publications Committee was presented. They have met with a Mr. Waldron and a Mr. Mencher, who have had experience in journalism and advertising. The committee is working on a plan or procedure for the operation of Mines Magazine. This plan or procedure will be presented to the Executive Committee as soon as it is completely formulated. Moved by Mr. Waterman the report be accepted. Seconded by Mr. Mathews. Passed.

Mr. Crabtree reported that the committee of Mr. Dudgeon, Mr. East and Mr. Crabtree, appointed for the purpose of recommending a replacement for Mr. Roll, had met but were waiting for the notice of the vacancy to appear in the magazine before acting.

Mr. Roll reported the November issue of the magazine had gone to press too soon to insert the announcement.

Mr. Mathews moved a letter be sent to every Alumnus advising the need of the Association to secure the services of an Executive Manager. Seconded by Mr. Waterman. Passed.

Methods of obtaining more advertising for the magazine were discussed. It was suggested that cigarette advertising might be acceptable.

Mr. Prosser announced that the Publisher's Press would like to work with the Association and the magazine.

The Annual Alumni Development Fund was discussed. This should be an alumni function but is not now so handled by the Alumni. It was suggested that better response would be obtained if the fund was handled by the Alumni directly.

Mr. Briber suggested the AADF be made one of the standing committees of the Alumni Association and that the appointed chairman of the AADF automatically be the Chairman of the Standing Committee.

Mr. Prosser announced that the annual meeting would be held on Jan. 28, 1960 at the Denver Athletic Club. The meeting will be advertised in the magazine.

Mr. Prosser suggested the Executive Committee take some action to combat the adverse publicity the school recently received in the local papers. The Executive Committee is in a much better position to take action than the School Administration.

Mr. Briber turned the meeting over to the Public Relations Committee

(Continued on page 36)

ALUMNI NEWS

Alumni Membership Card Mailings to be Discontinued

For many years Membership Cards have been mailed to Alumni upon payment of dues. The yearly cost of printing the card, postage and envelopes is about $150, not including time consumed for the operation.

The Executive Committee at the meeting of Nov. 18 decided to discontinue mailing of membership cards unless a receipt is specifically requested.

Harry J. Wolf, '03, Marries Miss Marguerite King

Harry J. Wolf, E.M. in '03 and M.Sc. in '13, and Miss Marguerite King were married Dec. 2 at the First Divine Science Church in Denver. Their home address is 3 Glenwood St., Little Neck 63, Long Island, N. Y.

Shortly after Christmas, Mr. and Mrs. Wolf flew to Paramaribo, Surinam, where Mr. Wolf will resume his exploration and development of gold and platinum placer properties in the wilds of southern Surinam as consulting engineer for the Surinam Development Corp.

Walter J. Tyler, '57, and Mrs. Tyler and young daughter joined the Wolfs on the flight to Paramaribo. Mr. Tyler will assist Mr. Wolf in the exploration and development of the placer deposits.

Caldwell, '50, Appointed Tax Law Specialist

David L. Caldwell, a 1950 mining engineering graduate of the Colorado School of Mines, has received an appointment as a tax law specialist with the U. S. Treasury Department in Washington, D. C.

After graduating from Mines, Mr. Caldwell went to work for Eastern Gas and Fuel Associates as a mining engineer at one of the company's West Virginia coal mines. He was recalled in 1951 to active duty by the Marine Corps for the Korean conflict, emerging in 1952 as a first lieutenant.

A further short period with Eastern Gas and Fuel Associates was followed beginning in early 1953 by several years with the Bureau of Mines' Branch of Bituminous Coal Research. In 1956 he transferred to the Bureau of Indian Affairs in Washington, D. C., first as a mining engineer and later as a minerals officer.

Mr. Caldwell completed the required work in 1956 for a law degree at American University and a year later was admitted to the Bar of the District of Columbia.

John H. Lowell's Co. Acquires Largest U. S. Asbestos Deposit

John H. Lowell, a student of mining engineering at the Colorado School of Mines both before and after his military service in World War II, is president of The Clute Corp., which recently acquired 100 per cent of the outstanding stock in Asbestos Bonding Corp. ABC holds a 99-year fee lease on the largest known chrysotile asbestos deposits in the United States, located near Napa, Calif.

Two years ago Mr. Lowell and Thomas H. Murphy formed the Clute Corp., an outgrowth of Clute Manufacturing Co., which for 30 years has been engaged in research, engineering and manufacture of air separation machinery. The corporation's patented air separation process—for movement and classification of materials through use of negative air pressure—may be applied in widely diversified industries: in the milling of minerals, grain and such commodities as coffee, sugar, nitrates, fertilizer, sand and gravel.

In the two years since the company was reorganized, Clute equipment has been researched and developed for more efficient milling of asbestos and mica. Mills have been installed at Napa, Calif., and Cordova, N. M.

Divisions of Clute Corp. are Clute Manufacturing Division at Rocky Ford and Denver, Colo., Asbestos Bond Corp., wholly owned subsidiary at Napa, Calif.; Mineral Industrial Commodities of America (MICA), Cordova, N. M., 15 per cent ownership; Clute Sales Corp., Littleton, Colo., recently formed to expedite sales of machinery and minerals; and Mountain States Research Ltd., designed for housing research activities.

Mr. Lowell is a partner and executive vice president in the investment firm of Lowell, Murphy and Company in Denver. He is also treasurer of the Lowell, Murphy Development Co. and president of the Littleton Savings and Loan Association in Littleton, Colo.

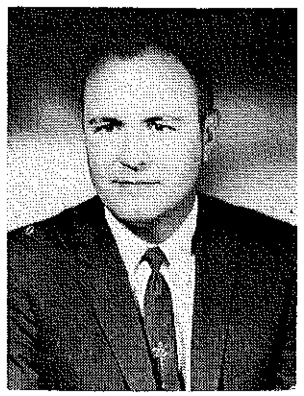
Oscar M. Davila, '47, Promoted To General Mill Superintendent

Oscar M. Davila, a 1947 metallurgical engineering graduate of the Colorado School of Mines, was recently promoted as general mill superintendent by Corporacion Minera de Bolivia, in charge of the supervision of all their concentrators. These operations cover a wide territory and will provide a variety of ore dressing problems.

After completing his post-graduate work at Missouri School of Mines and a special research project with tin ores at the Bureau of Mines, Rolla, Mo., Mr. Davila returned to his native land, Bolivia. Five months prior to his latest promotion, he was mill superintendent at the largest tin mine in Bolivia, Empresa Minera de Catavi.

Mr. Davila's present address is Superintendencia General de Ingenios, Casilla 626, Oruro, Bolivia.

Harrah, '42, in International Sales at Denver Equipment Co.



H. W. Harrah, a 1942 metallurgical engineering graduate of the Colorado School of Mines, has been transferred to the International Sales Division at Denver Equipment Co. He will be located in Denver and be responsible for sales activities in Canada, Australia, Japan, Burma and the Philippines.

An internationally known specialist in non-metallic flotation (a process of mineral beneficiation), he has been a sales engineer in the Domestic Sales Division of Denver Equipment Co. since 1945. He lives at 9570 W. 51st Ave., Arvada, Colo.

J. B. Willis, '57, Recounts Experiences in Saudi Arabia

This letter by John B. Willis gives his impressions of Saudi Arabia and tells about some of his experiences in the Land of Aladdin's Lamp. Willis received his MSc. degree in geological engineering at Mines in 1957.

Sept. 24, 1959

Mr. George H. Roll
Alumni Association
Golden, Colo.
Dear Mr. Roll:

Would you change my mailing address from Saudi Arabia to 430 No. Parkman Ave., Los Angeles 20, Cal., please? I'll be returning to the States by November.

My short stay in Saudi Arabia has been a very gratifying experience. The hospitality of the desert Arab is quite remarkable. Whenever you stop to talk to someone in the desert they insist on offering you coffee and tea and if you don't watch them carefully, they're liable to kill a sheep and make a big feast for you. Sometimes their cuisine is *not the best* but they gladly give a guest whatever they have.

The people with *special talents* for finding water are called sonants and for a good many centuries they have been doing quite well. In nearly every village I visited to locate water-well sites, a sonant had been over the ground previously; and after I marked the spots we would drill, the people would show me "witched sites" which generally proved to be in good locations (one or two later proved to be better than mine). It brought to mind some of Dr. Bob Carpenter's comments about keeping an open mind and not scoffing at ideas presented by non-college educated people.

The feeling of Arab Nationalism is quite strong here, and there is very little tension and unrest. They are generally happy and enjoy their way of life even though it is rigorous. In travelling around the kingdom you have to be very careful that someone doesn't jump in front of your car, and most of the local drivers act like they're still on camels, but aside from that there is no need to worry. Stealing and vandalism are practically non-existent, and if you should need a hand there's always someone ready to help.

Americans are generally well-liked here but little understood. Our engineers tend to isolate themselves in small groups and don't mix with the locals and thereby miss a valuable opportunity. It's like a dance where the boys stand on one side of the room and the girls on the other. A certain distant admiration results, but the fruits of a more intimate relationship are lost. I'm afraid that our diplomats act the same, as they visit with the king and generals and never come in contact with the people.

Well, in closing I'd like to say for anyone coming to Arabia, that if they like the desert and aren't bothered by having no TV, they'll find the Saudi Arabs are a very warm-hearted, friendly and interesting group.

Sincerely,
John B. Willis, '57

ALUMNI BUSINESS

(Continued from page 34)

for action to be approved by the Executive Committee.

Mr. Roll asked if it was really necessary to send membership cards to those paying their annual dues. He suggested that some money could be saved if cards were not sent.

Mr. Mathews moved that the Alumni Office discontinue sending membership cards unless they are specifically requested and that a notice of explanation be inserted in the magazine.

Seconded by Mr. Crabtree. Passed.

No further business appearing, the meeting was adjourned at 9:30 p.m.

CLASS NOTES

(Continued from page 16)

c/o Dhofar-Cities Service Petroleum Corp., Box 1201, Steamer Pt., Aden, Arabia.

Robert C. Bartlett's address is 12 Licata Tr., Cos Cob, Conn.

John C. Capshaw gives his address as Mecom Bldg. Box 2566, Houston 1, Texas.

James W. Faber, metallurgical engineer for Westinghouse Electric Corp., Aviation Gas Turbine Division, lives at 11605 Holmes Rd., Rt. 1, Grandview, Mo.

Graham B. Gibson, exploration geologist for Colombian Petroleum Co., has been transferred from Cucuta to Bogota, Colombia. His mailing address is Apartado Aereo 3434.

Newell H. Orr has moved from Denver to 451 Brown's Lane, Pittsburgh 37, Pa.

Aldon H. Strobeck's address is Box 592, Stanley, N. Dak.

Stewart W. Towle, now on furlough from Douglas Reduction Works, Phelps Dodge Corp., where he was assistant test engineer, is now a graduate student at the University of Arizona. His mailing address is 1817 E. 10th St., Tucson, Ariz.

1955

A boy, Mark Francis, was born Sept. 17 to the Arden L. Bement family. This brings the family tally to three boys and two girls. In November Arden attended a two-week training session at the Navy Amphibious Training School in San Diego through his Army Reserve program.

Hugh King has returned to Venezuela where he may be addressed c/o Creole Petroleum Corp., Lagunillas, Zulia, Venezuela, S. A.

George Kinsel's address is 619 S. Washington, Casper, Wyo.

1956

Edward J. Graeber, Jr., staff member for Sandia Corp., may be addressed at 3425 Inca St., N.E., Albuquerque, N. M.

K. William Jeffers' new mailing address is c/o U.S.C.& G.S., Norfolk District Office, 102 W. Olney Rd., Norfolk 10, Va. He was formerly in Portland, Ore.

1st Lt. George E. Reeves is fixed-and-rotary-wing pilot with the U. S. Army Corps of Engineers. His mailing address is Engr. Topo Section, U. S. Army Eng. Dist., Gulf, APO 205, New York, N. Y.

Richard H. Self, petroleum engineer, development and research, Standard Oil

(Continued on page 44)

IN MEMORIAM

Herbert Austin Everest

Herbert Austin Everest, "Bert" to his intimates, died at his home in Los Angeles, Oct. 30th, 1959, at the age of 72.

His was the class of '08. His degrees E.M. and E.Met.

A splendid athlete (high hurdles), tall, powerful, he had the great misfortune, ten years after graduation, while directing fire-fighting in a coal mine, to be hit and crushed by a fall of rock. It severed his spinal cord, an injury that kept him confined to a wheel chair the rest of his life.

In the ten years between graduation and the accident, Bert was active in mining and geology, first as chief of party with the Oklahoma Geological Survey, then as an independent consultant in petroleum geology in Texas, Oklahoma and Kansas; as part owner, superintendent and manager of Hazelton Coal Co., Coalgate, Okla. and also of the Southern Anthracite Coal Co., Russellville, Ark.

Following two years spent in the fight to live and regain some measure of health, he put his mind on radio research and became a consultant in electronics.

In 1933, finding the old-type, heavy wide, wooden wheel chair made him a home-bound invalid, he began developing his ideas of what was needed to liberate him. Thus the light-weight, folding, metal chair came into being. He acquired the assistance of a mechanical engineer, Mr. Harry C. Jennings, and organized the Everest & Jennings firm of which Bert was president for 20 years during which the company established its international outstanding reputation for service and quality.

In 1948 the company received a Presidential Citation for the employment of the handicapped. In 1953 the Colorado School of Mines awarded Bert its Distinguished Achievement Medal, the citation emphasizing the utilization of his engineering training to the great benefit of those handicapped by the inability to walk.

In May 1954 the National Society of Indoor Sports honored Bert with a Distinguished Service Award, and in November 1954 the Southern California District of Indoor Sports gave Bert a Citation for his work with the handicapped.

He wrote many articles in publications for the handicapped, their rehabilitation and employment. His mail brought actually thousands of letters from the handicapped to which he dictated responses. He made repeated visits to hospitals for the maimed and broken to evince the possibilities for usefulness.

His wife, Zoe Kline, to whom he was married four years before the accident, and his daughter, Mrs. Joseph T. Gregory, who survive him, gave to him a life-time of never faltering adoration, care, encouragement.

Bert was a valiant soul; an example of courage of the highest type and, withal, a modest, kindly, thoughtful gentleman.

Orvil R. Whitaker

Orvil R. Whitaker, 84, of 99 S. Downing St., Denver, Colo., died Thanksgiving Day, Nov. 26, 1959, at Rose Memorial Hospital. Burial was at Fairmount.

* * *

Behind this simple obituary notice in the Denver newspapers, lies the unsung saga of a useful man's life.

For all the years of an active mining career which began with his graduation from the Colorado School of Mines in 1898, "O. R." or "Whit" as his many friends knew him, was at once a friend and advisor, and, later a national authority in his field.

In his earlier days, he ranged over the United States, Mexico, Canada and Central America as an employee of several of the great mining companies in those countries.

Throughout this period, his natural abilities were enhanced by experience in operation, management and appraisal in connection with his profession.

By 1912, he had acquired such stature in that field that he was able to set himself up as a consultant. In that capacity, he was frequently called upon to aid companies in making major decisions. Not the least of his contributions, was the men whom he selected out of his broad field of friends for top-side jobs. Out of this side of his efforts, rarely talked about by him, came a devoted set of followers. The path to his Denver office was as often taken by men who came to sit at his desk for personal advice and help, as it was by hard pressed executives who sought assurance that their course of action was the right one.

When the Raw Materials Advisory Committee of the Atomic Energy Commission was created, he was named to it and there as in the commercial field, his views were accepted as the expression of a forthright man who never stooped to personal advantage nor sought popularity by saying always what men desired to hear.

No better expression of the type of man "Whit" was, could be found than that contained in the citation which accompanied an Award of Merit given to him in 1942 by the Colorado School of Mines as an expression of appreciation for his services as a trustee of that institution and for significant achievement in the mineral industry.

In essence, it describes him as the man he was—the ideal mining engineer. It discloses the traits which will cause him to be sorely missed throughout the engineering fraternity.

It follows in full. Quote:

AN ENGINEER:—

Devoted to thorough investigation of any problem; to the determination of all of the facts; to the selection with instinctive wisdom, those pertinent to the correct solution. Concerned with performance —oblivious of praise or remuneration.

A MAN:—

Critical of himself—tolerant of others; doubtful of his rights—certain of his obligations; humble in the evaluation of his own achievements — laudatory of another's success. A broad, balanced mind and a generous spirit.

Survivors include his wife, Mina K. Whitaker; two sons, O. R. Whitaker, Jr. and George B. Whitaker; a daughter, Mary W. Parsons; two brothers, Dr. Milton C. Whitaker and Fred Whitaker; and four grandchildren.

Harold E. Eads

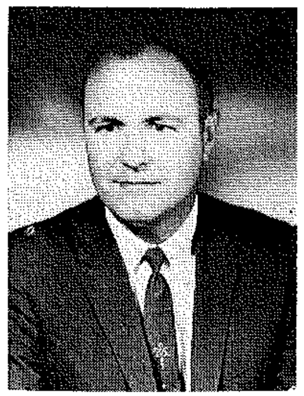
Robert W. Harrison, '33, has just sent us a notice of the death of Col. Harold E. Eads, x-'30, in Miami, Fla., on June 22, 1958. Mr. Harrison adds that although "Lefty" did not graduate, he was a prominent part of campus life while he was in school.

of all their concentrators. These operations cover a wide territory and will provide a variety of ore dressing problems.

After completing his post-graduate work at Missouri School of Mines and a special research project with tin ores at the Bureau of Mines, Rolla, Mo., Mr. Davila returned to his native land, Bolivia. Five months prior to his latest promotion, he was mill superintendent at the largest tin mine in Bolivia, Empresa Minera de Catavi.

Mr. Davila's present address is Superintendencia General de Ingenios, Casilla 626, Oruro, Bolivia.

Harrah, '42, in International Sales at Denver Equipment Co.



H. W. Harrah, a 1942 metallurgical engineering graduate of the Colorado School of Mines, has been transferred to the International Sales Division at Denver Equipment Co. He will be located in Denver and be responsible for sales activities in Canada, Australia, Japan, Burma and the Philippines.

An internationally known specialist in non-metallic flotation (a process of mineral beneficiation), he has been a sales engineer in the Domestic Sales Division of Denver Equipment Co. since 1945. He lives at 9570 W. 51st Ave., Arvada, Colo.

J. B. Willis, '57, Recounts Experiences in Saudi Arabia

This letter by John B. Willis gives his impressions of Saudi Arabia and tells about some of his experiences in the Land of Aladdin's Lamp. Willis received his MSc. degree in geological engineering at Mines in 1957.

Sept. 24, 1959

Mr. George H. Roll
Alumni Association
Golden, Colo.
Dear Mr. Roll:

Would you change my mailing address from Saudi Arabia to 430 No. Parkman Ave., Los Angeles 20, Cal., please? I'll be returning to the States by November.

My short stay in Saudi Arabia has been a very gratifying experience. The hospitality of the desert Arab is quite remarkable. Whenever you stop to talk to someone in the desert they insist on offering you coffee and tea and if you don't watch them carefully, they're liable to kill a sheep and make a big feast for you. Sometimes their cuisine is *not the best* but they gladly give a guest whatever they have.

The people with *special talents* for finding water are called sonants and for a good many centuries they have been doing quite well. In nearly every village I visited to locate water-well sites, a sonant had been over the ground previously; and after I marked the spots we would drill, the people would show me "witched sites" which generally proved to be in good locations (one or two later proved to be better than mine). It brought to mind some of Dr. Bob Carpenter's comments about keeping an open mind and not scoffing at ideas presented by non-college educated people.

The feeling of Arab Nationalism is quite strong here, and there is very little tension and unrest. They are generally happy and enjoy their way of life even though it is rigorous. In travelling around the kingdom you have to be very careful that someone doesn't jump in front of your car, and most of the local drivers act like they're still on camels, but aside from that there is no need to worry. Stealing and vandalism are practically non-existent, and if you should need a hand there's always someone ready to help.

Americans are generally well-liked here but little understood. Our engineers tend to isolate themselves in small groups and don't mix with the locals and thereby miss a valuable opportunity. It's like a dance where the boys stand on one side of the room and the girls on the other. A certain distant admiration results, but the fruits of a more intimate relationship are lost. I'm afraid that our diplomats act the same, as they visit with the king and generals and never come in contact with the people.

Well, in closing I'd like to say for anyone coming to Arabia, that if they like the desert and aren't bothered by having no TV, they'll find the Saudi Arabs are a very warm-hearted, friendly and interesting group.

Sincerely,
John B. Willis, '57

ALUMNI BUSINESS

(Continued from page 34)

for action to be approved by the Executive Committee.

Mr. Roll asked if it was really necessary to send membership cards to those paying their annual dues. He suggested that some money could be saved if cards were not sent.

Mr. Mathews moved that the Alumni Office discontinue sending membership cards unless they are specifically requested and that a notice of explanation be inserted in the magazine.

Seconded by Mr. Crabtree. Passed.

No further business appearing, the meeting was adjourned at 9:30 p.m.

CLASS NOTES

(Continued from page 16)

c/o Dhofar-Cities Service Petroleum Corp., Box 1201, Steamer Pt., Aden, Arabia.

Robert C. Bartlett's address is 12 Licata Tr., Cos Cob, Conn.

John C. Capshaw gives his address as Mecom Bldg. Box 2566, Houston 1, Texas.

James W. Faber, metallurgical engineer for Westinghouse Electric Corp., Aviation Gas Turbine Division, lives at 11605 Holmes Rd., Rt. 1, Grandview, Mo.

Graham B. Gibson, exploration geologist for Colombian Petroleum Co., has been transferred from Cucuta to Bogota, Colombia. His mailing address is Apartado Aereo 3434.

Newell H. Orr has moved from Denver to 451 Brown's Lane, Pittsburgh 37, Pa.

Aldon H. Strobeck's address is Box 592, Stanley, N. Dak.

Stewart W. Towle, now on furlough from Douglas Reduction Works, Phelps Dodge Corp., where he was assistant test engineer, is now a graduate student at the University of Arizona. His mailing address is 1817 E. 10th St., Tucson, Ariz.

1955

A boy, Mark Francis, was born Sept. 17 to the Arden L. Bement family. This brings the family tally to three boys and two girls. In November Arden attended a two-week training session at the Navy Amphibious Training School in San Diego through his Army Reserve program.

Hugh King has returned to Venezuela where he may be addressed c/o Creole Petroleum Corp., Lagunillas, Zulia, Venezuela, S. A.

George Kinsel's address is 619 S. Washington, Casper, Wyo.

1956

Edward J. Graeber, Jr., staff member for Sandia Corp., may be addressed at 3425 Inca St., N.E., Albuquerque, N. M.

K. William Jeffers' new mailing address is c/o U.S.C.& G.S., Norfolk District Office, 102 W. Olney Rd., Norfolk 10, Va. He was formerly in Portland, Ore.

1st Lt. George E. Reeves is fixed-and-rotary-wing pilot with the U. S. Army Corps of Engineers. His mailing address is Engr. Topo Section, U. S. Army Eng. Dist., Gulf, APO 205, New York, N. Y.

Richard H. Self, petroleum engineer, development and research, Standard Oil

(Continued on page 44)

IN MEMORIAM

Herbert Austin Everest

Herbert Austin Everest, "Bert" to his intimates, died at his home in Los Angeles, Oct. 30th, 1959, at the age of 72.

His was the class of '08. His degrees E.M. and E.Met.

A splendid athlete (high hurdles), tall, powerful, he had the great misfortune, ten years after graduation, while directing fire-fighting in a coal mine, to be hit and crushed by a fall of rock. It severed his spinal cord, an injury that kept him confined to a wheel chair the rest of his life.

In the ten years between graduation and the accident, Bert was active in mining and geology, first as chief of party with the Oklahoma Geological Survey, then as an independent consultant in petroleum geology in Texas, Oklahoma and Kansas; as part owner, superintendent and manager of Hazelton Coal Co., Coalgate, Okla. and also of the Southern Anthracite Coal Co., Russellville, Ark.

Following two years spent in the fight to live and regain some measure of health, he put his mind on radio research and became a consultant in electronics.

In 1933, finding the old-type, heavy wide, wooden wheel chair made him a home-bound invalid, he began developing his ideas of what was needed to liberate him. Thus the lightweight, folding, metal chair came into being. He acquired the assistance of a mechanical engineer, Mr. Harry C. Jennings, and organized the Everest & Jennings firm of which Bert was president for 20 years during which the company established its international outstanding reputation for service and quality.

In 1948 the company received a Presidential Citation for the employment of the handicapped. In 1953 the Colorado School of Mines awarded Bert its Distinguished Achievement Medal, the citation emphasizing the utilization of his engineering training to the great benefit of those handicapped by the inability to walk.

In May 1954 the National Society of Indoor Sports honored Bert with a Distinguished Service Award, and in November 1954 the Southern California District of Indoor Sports gave Bert a Citation for his work with the handicapped.

He wrote many articles in publications for the handicapped, their rehabilitation and employment. His mail brought actually thousands of letters from the handicapped to which he dictated responses. He made repeated visits to hospitals for the maimed and broken to evince the possibilities for usefulness.

His wife, Zoe Kline, to whom he was married four years before the accident, and his daughter, Mrs. Joseph T. Gregory, who survive him, gave to him a life-time of never faltering adoration, care, encouragement.

Bert was a valiant soul; an example of courage of the highest type and, withal, a modest, kindly, thoughtful gentleman.

Orvil R. Whitaker

Orvil R. Whitaker, 84, of 99 S. Downing St., Denver, Colo., died Thanksgiving Day, Nov. 26, 1959, at Rose Memorial Hospital. Burial was at Fairmount.

* * *

Behind this simple obituary notice in the Denver newspapers, lies the unsung saga of a useful man's life.

For all the years of an active mining career which began with his graduation from the Colorado School of Mines in 1898, "O. R." or "Whit" as his many friends knew him, was at once a friend and advisor, and, later a national authority in his field.

In his earlier days, he ranged over the United States, Mexico, Canada and Central America as an employee of several of the great mining companies in those countries.

Throughout this period, his natural abilities were enhanced by experience in operation, management and appraisal in connection with his profession.

By 1912, he had acquired such stature in that field that he was able to set himself up as a consultant. In that capacity, he was frequently called upon to aid companies in making major decisions. Not the least of his contributions, was the men whom he selected out of his broad field of friends for top-side jobs. Out of this side of his efforts, rarely talked about by him, came a devoted set of followers. The path to his Denver office was as often taken by men who came to sit at his desk for personal advice and help, as it was by hard pressed executives who sought assurance that their course of action was the right one.

When the Raw Materials Advisory Committee of the Atomic Energy Commission was created, he was named to it and there as in the commercial field, his views were accepted as the expression of a forthright man who never stooped to personal advantage nor sought popularity by saying always what men desired to hear.

No better expression of the type of man "Whit" was, could be found than that contained in the citation which accompanied an Award of Merit given to him in 1942 by the Colorado School of Mines as an expression of appreciation for his services as a trustee of that institution and for significant achievement in the mineral industry.

In essence, it describes him as the man he was—the ideal mining engineer. It discloses the traits which will cause him to be sorely missed throughout the engineering fraternity.

It follows in full. Quote:

AN ENGINEER:—

Devoted to thorough investigation of any problem; to the determination of all of the facts; to the selection with instinctive wisdom, those pertinent to the correct solution. Concerned with performance —oblivious of praise or remuneration.

A MAN:—

Critical of himself—tolerant of others; doubtful of his rights—certain of his obligations; humble in the evaluation of his own achievements — laudatory of another's success. A broad, balanced mind and a generous spirit.

Survivors include his wife, Mina K. Whitaker; two sons, O. R. Whitaker, Jr. and George B. Whitaker; a daughter, Mary W. Parsons; two brothers, Dr. Milton C. Whitaker and Fred Whitaker; and four grandchildren.

Harold E. Eads

Robert W. Harrison, '33, has just sent us a notice of the death of Col. Harold E. Eads, x-'30, in Miami, Fla., on June 22, 1958. Mr. Harrison adds that although "Lefty" did not graduate, he was a prominent part of campus life while he was in school.

CAMPUS HEADLINES

Intensive Science Program Major Change in Curricula

An intensive integrated science program is the major change in the Colorado School of Mines curricula, announced by Dr. John W Vanderwilt, Mines president.

The curricula changes—first in several years—were outlined at the School's monthly faculty meeting in December. The class changes resulted from a two-year study of the present curricula by the School's faculty, administration and board of trustees.

Major changes occurred in the supporting departments of mathematics, chemistry and physics. Also changed were the numbers of credit hours necessary for professional degrees in the six degree-granting departments at Mines. All changes become effective next fall.

Expanding Areas of Engineering

In commenting on the new requirements for a Mines degree, Dr. Truman H. Kuhn, dean of faculty, said "These changes have been made to insure preparing our students for the vastly expanding areas of mineral engineering. Since new and varied fields open each year, we are attempting to better acquaint our students with basic work and basic sciences in an integrated manner."

In addition to the science changes, the School also added six more semester hours of humanities—including courses in history, languages, economics and psychology—as requirements for each student. They will be required to take three of the humanity hours in either the freshman or sophomore year (making the lower division humanity requirements 15 semester hours) and the remaining three in the junior or senior year.

The School's Board of Trustees approved the changes and passed a resolution stating "We do not believe a student load of 60 hours a week is excessive." The average Mines student now carries 20 credit hours each semester (about four more than the normal college student); 31 actual hours of lecture and laboratory work each week; and spends about 30 hours a week at home preparing for the week's course work.

Integrated Teaching Programs

Physics, mathematics and chemistry departments have tightened integrated teaching programs which began several years ago. The faculty believes that, through integration of course material, the transition from beginning subjects to more difficult areas will result in greater retention of course material and ability to apply principles of science to their particular option courses.

In mathematics, all Mines students will be required to take at least 17 semester hours during their first two years. The four-semester math program combines elements of trigonometry, calculus, analytical geometery and differential equations. Previously the students had been required to take 20 semester hours of math the first two years, but the courses were not as closely integrated. The integration will also allow brighter students to proceed at a faster rate and enter more difficult classes earlier.

Nearly 50 per cent of the Mines students continue math studies in their junior and senior years—most of them taking courses in advanced calculus, statistics and numerical analysis.

Emphasis on Modern Physics

In physics, the changes are made to increase attention in modern physics. Previously required to take 10 semester hours of physics in the first two years, Mines students will now be required to take 13 hours—with the majority of the increase devoted to modern physics. The integrated course for freshmen and sophomores will combine elements of mechanics, wave motion, magnetism, heat, electronics, optics and nuclear physics.

Freshman and sophomore chemistry students will take two less semester hours now—a reduction to 16 from 18—but the emphasis on chemical principles has been increased. The chemistry classes will now be known as the four-semester program in Principles in Chemistry. The new program will combine elements and classification, atomic structure, molecular structure, chemical equilibria, chemical kinetics and advanced atomic and molecular structures.

Hours Necessary to Graduate

Also changed in the new curricula are the numbers of hours necessary for graduation. Formerly the School required undergraduates to take from 164 semester hours (in geology) to 153 hours (in metallurgy) for the first degree. Now the required hours will range from mining and geology with 158 to metallurgy's 152. In addition, all undergraduates will still be required to take from 13 to 15 semester hours of summer session courses and field work.

This year 1080 students are enrolled at Mines—10 per cent of whom are graduate students.

Captain Sutton Receives Commendation Medal

Capt. James L. Sutton, assistant professor at Mines, was recently presented with the Army Commendation Medal for meritorious service by PMST Lt. Col. Bruce D. Jones at a formation of the CSM ROTC cadet battalion. Captain Sutton, assigned to Mines from Greenland, was responsible for the construction of one of the eastern stations of the Distant Early Warning (DEW) Radar Line. He effectively coordinated the efforts of civilian contractors, Navy, Air Force, Coast Guard and Army transportation units to complete the job well ahead of schedule, despite the hazardous and unusual working conditions existing north of the Arctic Circle.

Mining Equipment Given To CSM Experimental Mine

Nearly $40,000 worth of mining equipment has been given to the Colorado School of Mines for use in the School's experimental mine at Idaho Springs, Colo.

The equipment—which previously had been used in the U. S. Bureau of Mines exploration work—has been moved to the School and will be installed in the Edgar Mine in the near future.

The mining items came from a list of excess expendable and non-expendable property which the U. S. Department of Interior offered to the mineral engineering college. Included are eight drifting drills, 19 jackhammer drills, accompanying machinery and various mountings, dies and drill steel.

The cost of the equipment to the Bureau is listed at slightly more than $8,000, but the same equipment pur-

chased new on the commercial market would cost at least five times that. The new additions of machinery bring the total amount of School-owned equipment in the Edgar Mine to $170,000.

The Edgar Mine is used to teach practical mining techniques and safety procedures to mining engineering students. The mine is also used as a tourist attraction during the vacation months. Last summer 11,000 visitors took guided tours of the former gold, silver, lead and zinc mine.

ROTC Rifle Team Moves to New Gym

The Colorado School of Mines ROTC rifle team has moved to its up-to-date range in the new gymnasium. John W Vanderwilt, president of Mines, fired off the first two shots for an eight and a nine to inaugurate use of the new facility.

Faced for many years with substandard range facilities, the Mines rifle team will have home shoulder-to-shoulder matches for the first time this year. M/Sgt. William King, coach of last year's Colorado-Wyoming Small Bore Rifle champs, hopes to see continued improvement in the Miners on the new range.

The 10-point range has firing lanes at distances varying from 25 feet to 1000 inches.

▼ Dr. John W Vanderwilt, CSM president, fires the first shot on the rifle range in the new gymnasium. In the foreground, left, is Sgt. William C. King, rifle team coach; in the background is Sgt. Walter E. Gilmore, administrative NCO.

CSM Engineer ROTC Graduates Rank Among Nation's Best

The School of Mines Engineer ROTC graduates continue to rank among the nation's best. Figures released by the army engineer school at Fort Belvoir, Va., show that 51 per cent of the Miners attending the school during the fiscal year 1959 ranked in the upper one-third of their class. Of 35 engineer ROTC units in the nation, only Rice Institute of Texas was able to outshine the Miners with a figure of 52 per cent in the upper third of the class.

During the fiscal year of record, Mines sent 41 students through the eight-week basic offiicers' course as compared to 21 from Rice. As a note of interest, during this period, only eight other schools in the nation, including the U. S. Military Academy, commissioned more officers in the Corps of Engineers than the School of Mines.

100 Enrolled at Mines For Graduate Degrees

Enrollment this fall of 100 graduate students at Mines (greatest number in the School's history) is distributed among the following departments: 28, geology; 25, geophysics; 15, mining; metallurgy, 10; 7, petroleum engineering; 3, petroleum refining; 3, combined options; 9, without option.

Twenty-four countries and 22 U.S. states are represented by the graduate students.

Sixty-six are candidates for Master's degrees, 15 for Doctor's degrees. The rest of the graduate students are either without options or within specific options, but not working for degrees.

George Morehouse Grant For Geology and Mining

A $2,230 grant to the Colorado School of Mines Foundation, Inc., will be used to purchase needed equipment for the School's mining and geology department. The grant was made by George E. Morehouse of Grand Junction, Colo.

Morehouse, a 1949 mining engineering graduate of the School, is a consulting engineer and geologist with offices in Grand Junction. He also received a master of science degree in geological engineering in 1950 from Mines.

The majority of the recent grant will be used to purchase a $1,730 Frantz Separator for the geology department. This equipment allows a rapid method of mineral separation through the use of changeable magnetic forces. The remaining $500 will be used to buy stress and strain gauge meters from the University of Durham (England). The equipment will be used both in class and research.

26-Game Basketball Schedule Announced by Brennecke

A 26-game basketball schedule for the 1959-60 season has been announced by Fritz S. Brennecke, director of athletics at the Colorado School of Mines.

Mines will play 18 Rocky Mountain Faculty Athletic Conference games, and splits its entire schedule with 10 home games and 16 on the road. Jimmy Darden, former AAU and professional player and coach, will enter his sixth year as head basketball coach.

The schedule of games still to be played is:

Sat. Jan. 16—at Colorado State College, at Greeley (RMFAC)
Mon. Jan. 25—at Colorado State College, at Greeley (RMFAC)
Fri. Jan. 29—Western State College, at Golden (RMFAC)
Sat. Jan. 30—Western State College, at Golden (RMFAC)
Wed. Feb. 3—at Colorado College, Colorado Springs (RMFAC)
Mon. Feb. 8—Colorado State College, at Golden (RMFAC)
Wed. Feb. 10—Air Force Academy, at Golden
Fri. Feb. 12—at Adams State College, Alamosa (RMFAC)
Sat. Feb. 13—at Adams State College, Alamosa (RMFAC)
Tue. Feb. 16—Colorado State College, at Golden (RMFAC)
Fri. Feb. 19—at Western State College, Gunnison (RMFAC)
Sat. Feb. 20—at Western State College, Gunnison (RMFAC)
Mon. Feb. 22—Colorado College, at Golden (RMFAC)
Fri. Feb. 26—at Idaho State College, Pocatello (RMFAC)
Sat. Feb. 27—at Idaho State College, Pocatello (RMFAC)

The Miners will have a basketball "home" for the first time in a dozen years this season. Work has been completed on the new Mines $1.1 million gymnasium, which contains a basketball arena. The arena can seat 1500 spectators for intercollegiate games. Since 1947 the Orediggers have been playing on a portable floor erected over Steinhauer Fieldhouse's clay surface.

(Continued on page 41)

FROM THE LOCAL SECTIONS

Minutes of Section Meetings should be in the Alumni Office by the 15th of the Month preceding Publication.

ALABAMA

Birmingham Section

Pres.: Joseph Hohl, '25
Sec.: Richard White, '42
249 Flint Dr., Fairfield

ARIZONA

Arizona Section

Pres.: Bob Thurmond, '43
V. Pres.: Gene Klein, '43
Sec.: Bill Bessinger, '50
6737 E. Koralee St., Tucson
Annual meetings: First Monday in December; 3rd Sunday in May (annual picnic).

Four Corners Section

See New Mexico for officers

CALIFORNIA

Bay Cities Section

Pres.: John D. Noll, '51
V. Pres.: Ralph D. Eakin, '48
Treas.: Herbert D. Torpey, '51
Sec.: Charles G. Bynum, '26
2810 Loyola Ave., Richmond

Southern California Section

Pres.: W. C. Prigge, '42
V. Pres.: R. E. McGraw, '53
Treas.: J. R. Leonard, '42
Sec.: M. C. McKinnon, '52
9826 Corella Ave., Whittier

COLORADO

Denver Section

Pres.: Ed. Haymaker, '41
V. Pres.: M. John Bernstein, '47
Sec.-Treas.: Douglas Rogers, '48
TA 5-2307

Four Corners Section

See New Mexico for officers

Grand Junction Section

Pres.: John Emerson, '38
V. Pres.: Tony Corbetta, '48
Sec.-Treas.: Joe Hopkins, Ex-'37
1235 Ouray Ave., Grand Junction

DISTRICT OF COLUMBIA

Washington, D. C. Section

Pres.: Charles T. Baroch, '23
V. Pres.: Vincent G. Gioia, '56
Sec.-Treas.: Thomas E. Howard, '41
9511 Nowell Dr., Bethesda 14, Md.
Luncheon meetings held every 2nd Thurs. noon at Sphinx Club, 1315 K St., N. W.

ILLINOIS

Great Lakes Section (Chicago)

Inactive

KANSAS

Kansas Section

Pres.: Francis Page, '39
Sec.: James Daniels, '51, AM 5-0614
205 Brown Bldg., Wichita
Meetings: Called by Sec. Contact Sec. for date of next meeting

LOUISIANA

New Orleans Section

Pres.: George Burgess, '49
V. Pres.: Emory V. Dedman, '50
Sec.-Treas.: Thomas G. Fails, '54
Shell Oil Co., Box 193, New Orleans

MINNESOTA

Iron Range Section

Pres.: Paul Shanklin, '49
V. Pres.: Leon Keller, '43
Sec.-Treas.: James Bingel, '53
50 Garden Dr., Mt. Iron, Minn.
Exec. Com.: Wm. Gasper, '43 and Robert Shipley, '52

MISSOURI

St. Louis Section

Pres.: Earl L. H. Sackett, '33
Sec.-Treas.: E. W. Markwardt, X-'32
621 Union Ave., Belleville, Ill.

MONTANA

Montana Section

Pres.: John Suttie, '42
V. Pres.: John Bolles, '49
Sec.-Treas.: Wm. Catrow, '41
821 W. Silver St., Butte

NEW MEXICO

Four Corners Section

Pres.: Dick Banks, '53
V. Pres.: Tony King, '57
Sec. Treas.: Tom Allen, '41

NEW YORK

New York Section

Pres. & Treas.: Ben F. Zwick, '29
Sec.: H. D. Thornton, '40
Union Carbide Corp.
30 E. 42nd St., New York City

OHIO

Central Ohio Section

Pres.: Roland Fischer, '42
Sec.-Treas.: Frank Stephens, Jr., '42
Battelle Mem. Inst., Columbus

Cleveland Section

Pres.: Charles Irish, '50
Treas.: Theodore Salim, '53

Pennsylvania-Ohio Section

See Pennsylvania for officers

OKLAHOMA

Bartlesville Section

Pres.: R. C. Loring, '37 and '39
V. Pres.: C. T. Brandt, '43
Sec.-Treas.: W. K. Shack, '51
4726 Amherst Dr., Bartlesville

Oklahoma City Section

Pres.: Lynn Ervin, '40
V. Pres.: Clayton Kerr, '30
Meetings the 1st and 3rd Tuesday of each month at the Oklahoma Club

Tulsa Section

Pres.: Parke Huntington, '26
V. Pres.: Jerry Diver, '52
Sec.-Treas.: Jim Newell, '52

PENNSYLVANIA

Eastern Pennsylvania Section

Pres.: Samuel Hochberger, '48
V. Pres., Sec-Treas.: Arthur Most, Jr., '38
91 7th St., Fullerton

Pennslvania-Ohio Section

Pres.: L. M. Hovart, '50
Sec.-Treas.: George Schenck, '52
7130 Thomas Blvd., Pittsburgh
Meetings upon call of the secretary

TEXAS

Houston Section

Pres.: Jack Earl, '53
V. Pres.: John C. Capshaw, '54
Sec.-Treas.: Nick Shiftar, '40
5132 Mimosa St.,
Bellaire, Texas

North Central Section

V. Pres.: Howard Itten, '41
Sec.-Treas.: Harley Holliday, '42
4505 Arcady Ave., Dallas 5
Sec.-Treas.: S Geffen, Ex-'42, Ft. Worth
Sec.-Treas.: John Thornton, '50
609-B Scott St., Wichita Falls

Permian Basin Section

Pres.: Van Howbert, '51
V. Pres.: Hal Ballew, '51
Sec.-Treas.: Tom McLaren, '52
P. O. Box 1600, Midland
Luncheon meetings held first Friday of each month at Midland Elk's Club.

South Texas Section

Pres.: James Wilkerson, '31
V. Pres.: Edward Warren, '50
Sec.-Treas.: Richard Storm, '53
1007 Milam Bldg., San Antonio

UTAH

Four Corners Section

See New Mexico for officers

Salt Lake City Section

V. Pres.: Joe Rosenbaum, '34
Sec.-Treas.: Kenneth Matheson, Jr., '48
614 13th Ave., Salt Lake City

WASHINGTON

Pacific Northwest Section

Pres.: Wm. Douglass, '11
Sec.: C. Ted Robinson, '53
16204 S.E. 8th, Belleview

WYOMING

Central Wyoming Section

Pres.: John Newhouser, '50
Sec.: Adolph Frisch, '53
2805 O'Dell Ave., Casper

LOCAL SECTIONS OUTSIDE U. S. A.

CANADA

Calgary Section

Pres.: R. F. Zimmerly, '47
V. Pres.: J. S. Irwin, Jr., '54
Sec.-Treas.: G. L. Gray, '50
1304 4th St. S.W., Calgary
Luncheon meetings held 3rd Monday of each month in Calgary Petroleum Club; visiting alumni welcome.

PERU

Lima Section

Pres.: Richard Spencer, '34
V. Pres.: Hernando LaBarthe, '42
Sec.-Treas.: Norman Zehr, '52
Casilla 2261, Lima
Meetings first Friday of each month, 12:30 p.m., Hotel Crillon (April through December), or on call.

PHILIPPINES

Baguio Section

Pres.: Francisco Joaquin, '26
V. Pres.: Claude Fertig, X-'27
Sec.: P. Avelino Suarez
Balatoc Mining Co., Zambales

Manila Section

Pres.: Servilano Aquino, '41
V. Pres.: Gus Neumann, '21
Sec.-Treas.: J. Kuykendall, '41

TURKEY

Ankara Section

Alumni visiting Turkey contact either: F. Ward O'Malley, '42, Explr. Mgr., Tidewater Oil Co., Kumrular Sokakb, Yenisehir Ankara; Tel. No. 21328.
Ferhan Sanlav, '49, Turkiye Petrolleri A. O. Sakarya Caddesi 24, Ankara; Tel. No. 23144.

VENEZUELA

Caracas Section

Pres.: William A. Austin, Jr., '27
V. Pres.: G. V. Atkinson, '48
Sec.-Treas.: T. E. Johnson, '52
c/o Phillips Petr. Co.
Aptdo 1031
Asst. Sec.-Treas.: R. L. Menk, '51
c/o Creole Petr. Corp.
Aptdo 889

Caracas Section

Caracas Section held an informal dinner meeting on Dec. 3. at the Centro Venolozano-Americano del Este.

New officers elected for the next term are: William A. Austin, Jr., '27, president; G. V. Atkinson, '48, vice president; T. E. Johnson, '52, secretary-treasurer; R. L. Menk, '51, assistant secretary-treasurer.

Bill Austin celebrated his election by picking up the bar bill.

Present at the dinner were:

F. H. Storms, '24; William A. Austin, Jr., '27; P. G. Sharp, '33; M. T. Rader, G. V. Atkinson, '48; R. L. Menk, '51; T. A. Garrity, '52; A. Nogales, '53; G. Adams, '57; John Christians, '58.

G. V. Atkinson, vice pres.

Grand Junction Section

The season started off with the "Setter Party" on schedule, Nov. 14. Cocktails and hors d'oeuvres at Setter's home. Dinner dance at Bookcliff Country Club 8 p.m. to midnight.

Fifty-five people were present: 22 members and wives, ten guests and one honorary member's wife (Mrs. W. G. Haldane). Mary Kay prepared the hors d'oeuvres and attended the cocktail party but had other business at dinner time.

Motica, Fulton and Kohler obtained ingredients and served drinks at Setter's in good style. The dinner menu was club steak with all the trimmings.

"The Knight Errants," a lively three-piece orchestra, kept everyone on their toes. When the orchestra quit at midnight, George Morehouse donated $15 to keep them going. Since the orchestra was a "special" we were charged $49 for it, so a "Thunder-mug" was placed at the door of Setter's home and as people left they donated what they saw fit. We "took" $37.25 for the kitty—John Mitchell counted their change and encouraged them to contribute.

Corbetta and Hopkins collected $5 per head from the members for the dinner, to keep the books almost even.

Those attending were:

Bob and Jenny Barney, Duane and Marian Bauman, Tony and Lucille Corbetta, Bob and Bell Daniel, John and Mary Emerson, Dave and Jeanne Fulton, Mrs. W. G. Haldane, Dutch and Dottie Hildebrand (Guests Mr. and Mrs. Max Welch), Joe and Ellen Hopkins, Mary Kay, Doug and Bonnie Kaasch (Guests Mr. and Mrs. Warner), Bill and Marion Kohler, Tim and Mrs. McCandless, John and Ruth Motica, George and Ruth Morehouse, John and Jean Mitchell, Dick and Lois Philippone, Bill and Helen Rump, Mark and Elain Shipman, Allan and Dorothy Simpson, Bob and Bonnie Saer, Tony and Kay Setter (Guests Mr. and Mrs. Ary and Reynolds), Charlie and Shirley Woodard, Frank and Ruth Woodard.

Next party will start with cocktails in the Simpson Cross Cut with dinner dance at the Caravan Mess Hall on Saturday, Jan. 23, with Alan and Dorothy Simpson as host and hostess.

Joe Hopkins, Jr., secretary

Houston Section

The Houston Section held its monthly luncheon on Friday, Nov. 13 at the Houston Club. This meeting had been delayed to accommodate Miners who might be attending the geologists and geophysicists convention. Several were in attendance. I was particularly pleased to meet an old friend, Chuck Thurber, '39.

Bob Turley, '52, reported briefly on some of the subjects of interest which were discussed at the convention.

John Biegel, '39, talked briefly about the luncheon to be held Dec. 29. At this meeting we hope to bring together some of the mine students who live in Houston and prospective students who may be considering enrolling at Mines. John Capshaw will communicate with the registrants with the objective of publicizing this luncheon.

Miners attending the Nov. 13th luncheon were:

Albert G. Wolf, '07; L. R. Van Burgh and S. A. Mewherter, '17; George B. Somers, '30; I. G. Burrell, '31; R. A. Kerr, '36; Raymond Snyder, '37; Chuck Thurber and John Biegel, '39; Nick Shiftar, '40; Gil Fabre, '47; Lee R. Jamison, '49; M. Malek Osloni and Art Dickenson, '50; Bill Johnson, James Grimes and Bob Owen, '51; Jim Ogg, Dick Wise, Bob Turley and C. W. Leaf, '52; Dale R. Hieger and Tom Rollins, '53; John Capshaw, '54; Hershal C. Ferguson, Jr., '58.

Nick Shiftar, sec.-treas.

Houston Section held its monthly luncheon on Dec. 2 at the Houston Club. Plans are going forward to hold the sons and dads luncheon for prospective "Mines" students on Dec. 29.

Miners attending the Dec. 2 luncheon were:

Albert G. Wolf, '07; S. A. Mewhirter, '17; Jim Ballard, M. L. Euwer, D. M. Davis, '25; Don I. Gahagan, '27; R. W. Snyder, '37; J. Biegel, '39; J. Pawly, Nick Shiftar, '40; Gilbert Fabre, '47; Jack Warren, '50; Bob Turley, Jim Ogg, John Dingman, '52; Howard Kaylor, '53.

Southern California Section

The Southern California Section met Oct. 22, the occasion being the fall regional meeting of the Society of Petroleum Engineers of AIME. The section sponsored a cocktail party and open house at the Huntington Sheraton Hotel in Pasadena. Several alums and their guests enjoyed the hospitality and fellowship, and a friendly game of chance helped defray the expenses of the evening.

The section will hold its winter meeting Jan. 15, at the Engineers Club of Los Angeles in the Biltmore Hotel. It will be a dinner meeting with wives and guests invited. Social hour at 6:30; dinner at 7:30. Reservations may be made by calling Murray McKinnon at Raymond 3-8631 or Oxbow 8-2201.

We will have the annual election of officers at this meeing.

We sadly report the death of Mr. H. A. Everest on Oct. 30, in Hollywood, Calif.

M. C. McKinnon, secretary

Tulsa Section

Tulsa Section held a dinner meeting on Dec. 2. A general discussion and renewing acquaintances was the order of business.

Present at the meeting were:

Mike Kiess, '25; Harold Haight, '27; Vernon Peterson, '30; John Rupnik, '33; Eddit Chapman, '35; John Haley, '48; Merton Whitlow, '49; Jack Weyler, '50; Chester Westfall, J. W. Newell, '52. Arnold Bunte, '26, of Roswell, N. M., along with Jim Ballard, '40, and John Ross of Wichita, Kans., were out-of-town guests.

J. W. Newell, sec.-treas.

CAMPUS HEADLINES

(Continued from page 39)

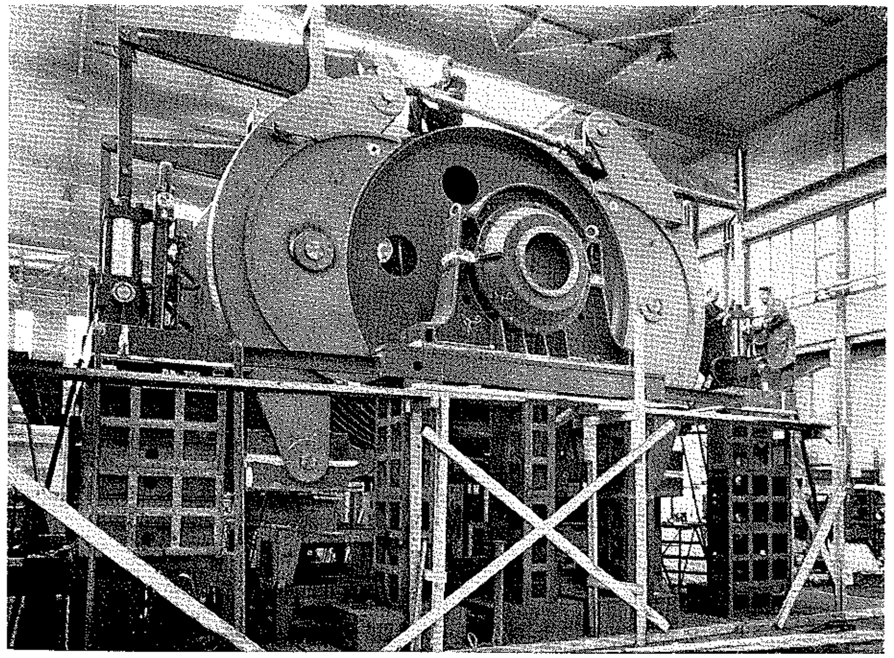
Post Football Season Honors Handed Out at CSM Banquet

Post football season honors were handed out Dec. 16 at the annual Colorado School of Mines football banquet.

Center Bob Smith, four-year letterman and three years the starting pivot for the Orediggers, was elected honor-

(Continued on page 46)

PLANT NEWS



▼The machinery for ASEA's giant mine hoist is designed for 12,000 h.p. and a driving speed of 14 metres per second. (Photo courtesy of American Swedish News Exchange, Inc.)

World's Largest Mine Hoist Delivered by ASEA to Russia

What is claimed to be the world's largest mine hoist is being delivered by the Swedish General Electric Company (ASEA), in Vasteras, to the Soviet Union. It is intended for a double hoist system with a loading capacity of 50 tons per skip and forms a part of a delivery of nine hoisting units. Still another hoist is of the same size.

The hoist drum weighs 49 tons, and its two skips weigh 40 tons each. For lifting the drum out of the construction hall, it was necessary to build new traversing gear. In spite of the heavy capacity of the pulley unit, its diameter is only 14 feet, as its hauling capacity is distributed over eight wires, as against a maximum of four wires in other large-size driving pulleys.

The driving speed is 33 feet per second at a depth of 3,000 feet. The motor effect is 9,000 h.p., derived from four separate units which are connected to the driving wheels by means of two double-reduction precision gears. The motors are connected to the transformers by Leonard gearing.

However, the mechanical equipment is designed for an ultimate depth of 3,900 feet, which will mean an increase in the driving speed to 14 meters, or 42 feet, per second at a simultaneous increase in the motor effect to 12,000 h.p.

The delivery of the hoists, which are wholly automatized, includes ASEA-made skips, measuring pockets, wires, and underground transportation equipment for conveyance of the ore from the crushing stations. The last mentioned are to be operated by an ASEA automatic hopper system, adjusted to the automatic hoisting method.

WKE to Design AS&R Mill

Western-Knapp Engineering Co. of San Francisco, Calif., has been awarded a contract to design and engineer the 15,000 ton per day copper flotation concentrator for American Smelting and Refining Co.'s Mission Project near Tucson, Ariz. The copper concentrator is the major construction item in the Mission Project. Cost of the total project, scheduled for completion in 2½ years, has been estimated at over $40,000,000.

The Western District Office of WKE will design the copper concentrator in its San Francisco Engineering Center. The mill will be one of the most efficient of its kind, incorporating the newest metallurgical techniques, and employing many automatic measuring and control devices. It is estimated that the annual throughput of the mill will be 5,400,000 tons, producing approximately 45,000 tons of copper per year.

Ohio Oil Plant Being Built By Stearns-Roger Mfg. Co.

The Ohio Oil Co. has let contract to the Stearns-Roger Manufacturing Co. of Denver for design and construction of a casinghead gas processing plant to serve the rapidly developing Scipio, Pulaski and Albion fields of south central Michigan.

The plant will be an absorption-refrigeration type gas processing and sweetening facility with vessel capacity of 25 million cubic feet daily and compressor capacity of 10 million cubic feet. The plant will initially produce 40,000 gallons of liquefiables daily and eventually production will be boosted to 65,000 gallons. Liquids to be extracted are propane and a mixture of butane and natural gasoline.

Contractor expects to break ground on site five miles north of Jonesville early in February with completion scheduled by mid-1960.

Hitch, Boling to Direct Dorr-Oliver Incorporated

L. R. BOLING

J. D. HITCH, JR.

The Board of Directors of Dorr-Oliver Incorporated recently appointed J. D. Hitch, Jr., president, to fill its vacant board chairmanship and elected L. R. Boling, currently executive vice president, to succeed Mr. Hitch as president. Both appointments became effective Dec. 1, 1959, with Mr. Boling continuing as chief executive officer of the internationally known engineering concern. Dr. John V. N. Dorr and Wm. L. Oliver will continue as honorary chairman and vice chairman of the Board respectively.

A civil engineering graduate of Harvard, Mr. Hitch joined the former Dorr organization in 1927. After six years as the company's representative in Japan, he was appointed export manager in 1935. He was successively elected vice president for sales and a director of the corporation, executive vice president, and president in 1953. With the merger of Dorr and Oliver organizations in late 1954,

(Continued on page 45)

BOOK REVIEWS

Bibliography of Stable Isotopes Of Oxygen (O^{17} and O^{18})

Reviewed by George B. Lucas, Department of Chemistry, Colorado School of Mines.

Compiled and edited by David Samuel and Fritz Steckel; Pergamon Press; 224 pages.

One of the many barriers that nature has placed in the way of scientific investigation is the non-existence of radioactive isotopes of oxygen and nitrogen of sufficiently long half-life to permit their frequent use in radioactive tracing experiments. The longest lived isotope of oxygen is O^{15} with a half-life of 2.1 minutes. This half-life is far too short for many desirable tracer experiments. Thus workers interested in following the path of oxygen in complex sequences must resort to the stable isotopes of oxygen (O^{17} and O^{18}). The techniques and equipment required for such a study have no doubt prevented many workers from following an interesting line of investigation. The compilation of this Bibliography by Samuel and Steckel may help convince some investigators that mass spectrometric techniques involving stable oxygen isotopes will yield an answer to their problem.

The main section of the book is arranged in alphabetical order of the principal investigator. The title of the paper, the journal in which it appeared, and the Chemical Abstract reference is given. When known, the institution in which the investigation was conducted is included. Each entry is identified by a letter-number combination which permits cross reference to entries under a co-author's name. The second portion of the book is a subject index, arranged alphabetically, which includes the previously mentioned letter-number identification and a further number; the year of the publication.

The compilation is complete through the year 1957 and covers all fields of endeavor in which isotopic oxygen figures. This bibliography should be a handy reference source for all interested parties, and should serve as an introduction to the literature for workers who would like to become acquainted with the techniques and methodology of isotopic ratio measurements.

This reviewer is somewhat puzzled by the arrangement of the book. Far greater utility would have been realized if the major indexing were by subject matter rather than by author. Most workers in a field, and particularly new entrants, are most interested in surveying an overall area of research. The actual arrangement of the bibliography makes this survey more difficult than it need be.

Nevertheless, this bibliography is a worthwhile compilation and is recommended to those interested in the area of non-radioactive isotopes and tracer methods.

Science and Resources

This book, published for Resources for the Future by The Johns Hopkins Press, is based on lectures given at the 1959 Resources for the Future Forum in Washington. The papers were edited for publication by Henry Jarrett of the RFF staff.

"Recent advances in science and technology," the book's introduction states, "already are strongly influencing the production and use of natural resources, and will have even larger effects in the future." The 18 essays explore the nature of some of the new discoveries and their possible economic and social impacts.

For each of six topics (genetics, weather modification, minerals, chemical technology, nuclear energy, outer space), a natural scientist tells where research in that field stands now and where it seems to be going, and two other authorities examine the implications from their particular viewpoints—businessman, government administrator, economist, political scientist, etc.

Dr. James Boyd, who obtained his M.Sc. and D.Sc. degrees from the Colorado School of Mines (1932 and 1934), is one of three men writing on the subject of "Exploring for Minerals." Dr. Boyd is vice president in charge of exploration, Kennecott Copper Corp.

Survey of Gold Situation

An inspective survey — mineral, economic and political — of the world's gold situation is the topic of the November Mineral Industries Bulletin. The 16-page Bulletin, published by the Colorado School of Mines, is written by Donald R. Williamson, project engineer and resident author at the CSM Research Foundation.

Williamson outlines the various gold standards now employed by nations throughout the world and discusses the problems connected with a possible gold value increase.

At one time the United States had 60 per cent gold backing for its currency. It now has 40 to 25 per cent. "Such small backing requires that currency be made inconvertible," says Williamson. "Obviously, the present U. S. gold reserves, priced at $35 an ounce, are already overburdened. That they are envied by other nations indicates the status of other reserves."

The $35 per ounce value was established in 1934. Current economic pressures have led some people to demand higher gold prices, some even urging a price of $105 per ounce.

The United States, with 10 per cent of the world's population, has more than half of the known gold reserves. Production of gold has been fairly steady for many years, but new uses for gold continue to increase, thereby reducing the amount of gold which could bolster the dwindling world reserves.

Gold's use in commercial ventures such as jewelry is increasing. An appreciable amount is being used in research for a universal measure of distance. It's also being used to coat jet planes and missiles.

Williamson's survey includes a discussion of new areas to be explored for gold. These include deep ore bodies and ocean waters. He also outlines ore, placer and hydrothermal deposits now known and suggests future production and exploration.

The November MIB is available without charge, at the Department of Publications, the Colorado School of Mines, Golden.

Discussion of Clay Terrain Construction Problems

A practical discussion of clay terrain construction problems is the topic of the most recent Colorado School of Mines Quarterly. The book is a compilation of papers dealing with the theoretical and practical treatment of expansive clays.

The Quarterly (Vol. 54, No. 4, price $2) is an outgrowth of the First Annual Soil Mechanics Conference, held in April at Mines. The papers discuss the problems of building on the expansive soils of the Middlewestern and Southwestern areas of the United States.

Included in the Quarterly are papers by Raymond E. Means, professor of architecture, Oklahoma State University; Dr. T. William Lambe, head of MIT's soil engineering department; Chester McDowell, supervising soils engineer for the Texas Highway Department; Raymond F. Dawson, civil engineering professor at the University of Texas; and W. G. Holtz, earth laboratory branch chief, U. S. Bureau of Reclamation.

Report on Franciscan Chert In Concrete Aggregates

A report containing vital economic information for the construction industry has just been released by the State of California Division of Mines. Special Report 55, "Franciscan chert in California concrete aggregates," by Harold B. Goldman, is especially timely in view of the tremendous highway building program planned for the next decade and already initiated. This program will demand concrete aggregate from new and expanding deposits as yet relatively unexploited.

Laboratory test data and the results of field examination of concrete structures and gravel deposits document the author's conclusions.

Available from the Division of Mines, Ferry Bldg., San Francisco for 50c plus tax.

Proceedings of the Third Annual Rock Mechanics Symposium

Colorado School of Mines Quarterly, Vol. 54, No. 3, 370 pages, price $3. Proceedings of the Third Annual Rock Mechanics Symposium, held April 20-22 at the Colorado School of Mines, have been published as a CSM Quarterly.

The symposium was divided into four major sections, each dealing with a distinct area of rock mechanics. They treated nuclear blasting, geophysics, soil and rock mechanics factors, and common underground and explosive failures.

Included among the papers are those of Dr. Leopold Muller, president of the International Assn. of Geomechanics, Germany; L. E. Djingheusian, senior Canadian Dept. of Mines engineer; Ulf Langefors, Nitrolglycerin Aktiebolaget physicist, Sweden; Sir Harold Jeffreys, Plumian Professor of Astronomy and Experimental Philosophy, Cambridge University, England; Dr. John S. Rinehart, head of the CSM mining engineering research laboratories; and a nuclear blast summation by four staff engineers of the Lawrence Radiation Laboratory of the University of California.

Cochise County Geologic Map

Cochise County is the subject of the latest geologic map to be issued by the Arizona Bureau of Mines at The University of Arizona. It is the sixth in a series of geologic maps being prepared for all Arizona counties. Developed on a scale of 1 to 375,000 inches, the map depicts detailed geologic conditions in Cochise County, as well as the topography and cultural features, such as roads and towns.

Printed in color, the map includes an explanatory guide to the location of different types of sedimentary, metamorphic and igneous rocks, as well as a color key showing the sources of the geologic data included in the map.

Dr. J. D. Forrester, director of the Arizona Bureau of Mines, said the Cochise map is "designed to serve many useful purposes, not only for the mineral expert, but for the public as a whole."

The Cochise geologic map, as well as the other five maps already issued, may be secured from the office of the Director, Arizona Bureau of Mines, The University of Arizona, Tucson, at .75 cents a copy.

Helium Extraction in Canada

A gap in the historical record of the early research on helium gas in Canada is filled by John Satterly, professor of physics, University of Toronto, Toronto, Canada, who narrates from memory and from notes his recollections of the origin and progress of the 1915-1920 helium project sponsored in Canada by the British Admiralty in an effort to obtain helium for use in lighter-than-air ships.

Details are given of the staff concerned; of the first experimental extraction plant at Calgary, where, from early 1918 to April 1920, about 60,000 cu. ft. of helium of 60 to 90 per cent purity was recovered from Canadian natural gas from the Bow Island (Alberta) field.

Mines Branch Information Circular IC 105 was published by the Dept. of Mines and Technical Surveys, Ottawa, Canada; price 25 cents.

Petroleum Industry in Kansas

The Kansas petroleum industry can remember 1958 as a year of some pleasant surprises in oil and gas developments and exploratory activity, despite a production decline that brought value of raw petroleum products from 458 million dollars in the peak year of 1957 to 432 million dollars in 1958.

"Oil and Gas Developments in Kansas During 1958" by E. D. Goebel, P. L. Hilpman, and D. L. Beene, by the State Geological Survey at The University of Kansas, records and evaluates the year's activities.

A highlight of the year's developments, according to the report, was the discovery of the Llanos oil field, Sherman County, which opened northwest Kansas to intensive exploration. Before the end of the year, other oil fields were opened in the area—for example, the Sappa Creek field, Rawlins County, and the Rueb field, Cheyenne County. The Rueb field, 30 miles

(Continued on page 45)

CLASS NOTES

(Continued from page 36)

Co. of Calif., has moved from La Habra, Calif., to Vernal, Utah. His P. O. Box is 455.

John Sulzbach is project manager trainee, Heavy Construction Division, Henry J. Kaiser Co. He lives at Apt. 5, 451 Wayne Ave., Oakland 6, Calif.

M. Donald Wagner is production engineer for Mobil Oil Co. de Venezuela with mailing address Apartado del Este 5393, Caracas, Venezuela.

1957

Guymon E. Adams is geophysical interpreter for Creole Petroleum Corp. He has moved from Pleasant Grove, Utah, to Caracas, Venezuela, where his mailing address is c/o Creole Petroleum Corp. Geofisica, Apartado 889.

John P. Allen, department head for Union Carbide Nuclear Corp., has moved from Tarentum, Pa., to Uravan, Colo.

Robert T. Beckman, mining engineer in the Division of Mineral Resources, U. S. Bureau of Mines, has moved from Julesburg to 701 S. Emerson, Denver 9, Colo.

William T. Larsen has left Mountain View, Calif., for 2446 Walnut Grove Ave., San Jose 28, Calif.

Dale L. Pinkerton was recently transferred to the Denver office of Ingersoll-Rand as mining and construction representative in the Colorado and northern New Mexico area. For the past 2½ years Dale has been with the New York headquarters office of Ingersoll-Rand as sales engineer in the rock drill department. The Pinkertons, now a family of four, have their home at 6447 Lee St., Arvada, Colo.

Z. A. Sancevic, exploitation engineer for Cia Shell de Venezuela Ltd., is on leave to take graduate work at Pennsylvania State University, College of Mineral Industries, Planning Department, University Park, Pa.

Kenneth A. Wagner, petroleum engineer for Amerada Petroleum Corp., has moved from Manhattan, Kans., to Charlston, N. Dak. His P. O. Box number is 77.

Charles R. Wood has been promoted from second lieutenant to first lieutenant. His mailing address is 1st Lt. Charles R. Wood 05504462, Hq. 79th Engr. Gp. (Const.), Ft. Belvoir, Va.

1958

Douglas P. Hildenbrandt has moved from Greeley, Colo., to 1416 E. Fair Oaks Ave., So. Pasadena, Calif.

Glen D. Cheney, office engineer for Ingersoll-Rand Co., has moved from Bairoil, Wyo., to 820 Simms St., Golden, Colo.

Bruce E. Russell, mine geologist for Cliffside Mine, Phillips Petroleum Co., lives at 431 N. Iron St., Grants, N. M.

Peter J. Sanger has moved from Purcell, Okla., to 4225 S. Broadway, Englewood, Colo.

William H. Wahl has moved from El Cerrito, Calif., and now lives at 2555 Duke, Richmond, Calif.

Ens. Charles J. Wideman, 2707 E. Adams St., Tucson, Ariz., graduated Nov. 20 from the Navy's Officer Candidate School in Newport, R. I. He was one of 722 officer candidates to complete the 18 weeks of intensive training in the naval sciences.

1959

William D. Gay, mining engineer for Union Carbide Nuclear Trace Elements Corp., has moved from Maybell, Colo., to 6th and Green Sts., Craig, Colo.

Robert A. Lame's address is 1143 E. Garvey Blvd., West Covina, Calif.

Ensign Craig S. Martenson graduated on Nov. 20 from the Navy's Officer Candidate School in Newport, R. I. His mailing address is 180 Oaks Rd., Framingham, Mass.

Charles H. McKinnis is a second lieutenant in the U. S. Army. His mailing address is 95 Brentwood, Lakewood, Colo.

Gary E. Melickian, a graduate student at the University of California at los Angeles, has moved from Sylmar, Calif. to 212 Bonita, Apt. 8, Arcadia, Calif.

Mr. and Mrs. Steven L. Milne announce the birth of a son, Scott Alan, Nov. 29. The Milnes live at 2325 28th St., Boulder, Colo.

Douglas M. Ross has moved from Golden, Colo. to 1416 E. Fair Oaks Ave., South Pasadena, Calif.

James R. Swaisgood is on a six months tour of duty with the U. S. Army. His mailing address is Box 402, Rt. 3, Ft. Collins, Colo.

Richard T. J. Whittington's address is 1304 E. Jax, Midland, Texas. He is employed by the R. H. Ray Geophysical Co.

Mr. and Mrs. George N. Brown, Jr., are parents of a daughter, Janel Rene, born Nov. 24 at Kadlec Hospital in Richland, Wash. Mrs. Brown was the former Miss Joyce Rapp of Golden. Mr. Brown is employed in Reactor Technology and Operations with General Electric Co. at the Hanford Atomic Products Operation in Richland.

1960

B. Frank Porter, who receives his E.M. degree in January 1960, has become the first active member of the Alumni Association of the Class of '60.

ADDRESS CORRECTION NOTICE

To receive your Mines Magazine regularly—keep us advised of your correct address.

Name ____________________

Address ____________________

Position ____________________

____

Company Connection ____________________

____

____

USE FOR CLASS NOTES

You want to read about Mines Men. *They* want to read about you.

Address: Colorado School of Mines Alumni Assn., Golden, Colo.

BOOK REVIEWS

(Continued from page 44)

from the nearest producing area, gave Cheyenne County its first commercial oil production.

Copies of "Oil and Gas Developments in Kansas During 1958" (Bulletin 138) may be obtained for $1 each from the State Geological Survey, The University of Kansas, Lawrence, Kan.

Survey of Canadian Iron Ore Industry During 1958

The Department of Mines and Technical Surveys, Mineral Resources Division, Ottawa, Canada, offers Mineral Information Bulletin MR 31, by T. H. Janes and R. B. Elver, price 50 cents.

This publication provides a detailed study of the production, trade and developments of the iron ore industry in Canada during 1958. Maps showing the properties in production, properties under development for production within the next few years, and properties on which exploration of iron-bearing material is taking place are included. The text is supported by tables and graphs dealing with production, consumption, and trade in iron ore.

PLANT NEWS

(Continued from page 42)

he became president and a director of Dorr-Oliver Inc. During World War II, Mr. Hitch served as a civilian technical advisor in China for the U. S. Government.

Mr. Boling joined the company in 1941 following eight years with California Spray Chemical Corp. A graduate of the University of California, he served successively as assistant controller, controller, secretary and treasurer of the former Oliver United Filters organization. When they merged with The Dorr Company in late 1954, he became vice president for finance and a director of the new corporation. On Jan. 1, 1959, he became vice president for operations coordination and on June 15 was elected executive vice president and chief executive officer.

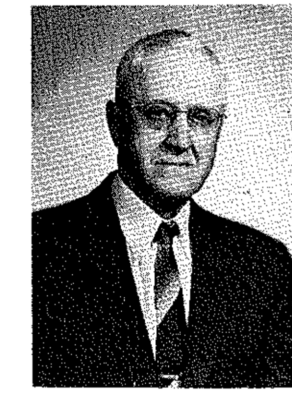
Gardner-Denver, Apex Will Merge on March 1

G. V. Leece, president of Gardner-Denver, has announced that Apex Machine & Tool Co. of Dayton, Ohio will become a wholly-owned subsidiary of Gardner-Denver on March 1, 1960.

Apex is a leading manufacturer of screwdriver bits and sockets for power tools. The company also is an important producer of universal joints for machinery and aircraft. In Gardner-Denver's line of equipment for industrial production are power screwdrivers and nutsetters that utilize Apex bits and sockets.

Gardner-Denver is celebrating its Centennial this year as a world-wide industrial firm.

Clarence Thom Will Be Consulting Metallurgist



Clarence Thom, director of the Denver Equipment Co.'s Ore Testing Division for nearly 25 years, has assumed new responsibilities, consulting metallurgist for Denver Equipment Co. and their many customers.

ADVERTISERS' LISTINGS

showing the sources of the geologic data included in the map.

Dr. J. D. Forrester, director of the Arizona Bureau of Mines, said the Cochise map is "designed to serve many useful purposes, not only for the mineral expert, but for the public as a whole."

The Cochise geologic map, as well as the other five maps already issued, may be secured from the office of the Director, Arizona Bureau of Mines, The University of Arizona, Tucson, at .75 cents a copy.

Helium Extraction in Canada

A gap in the historical record of the early research on helium gas in Canada is filled by John Satterly, professor of physics, University of Toronto, Toronto, Canada, who narrates from memory and from notes his recollections of the origin and progress of the 1915-1920 helium project sponsored in Canada by the British Admiralty in an effort to obtain helium for use in lighter-than-air ships.

Details are given of the staff concerned; of the first experimental extraction plant at Calgary, where, from early 1918 to April 1920, about 60,000 cu. ft. of helium of 60 to 90 per cent purity was recovered from Canadian natural gas from the Bow Island (Alberta) field.

Mines Branch Information Circular IC 105 was published by the Dept. of Mines and Technical Surveys, Ottawa, Canada; price 25 cents.

Petroleum Industry in Kansas

The Kansas petroleum industry can remember 1958 as a year of some pleasant surprises in oil and gas developments and exploratory activity, despite a production decline that brought value of raw petroleum products from 458 million dollars in the peak year of 1957 to 432 million dollars in 1958.

"Oil and Gas Developments in Kansas During 1958" by E. D. Goebel, P. L. Hilpman, and D. L. Beene, by the State Geological Survey at The University of Kansas, records and evaluates the year's activities.

A highlight of the year's developments, according to the report, was the discovery of the Llanos oil field, Sherman County, which opened northwest Kansas to intensive exploration. Before the end of the year, other oil fields were opened in the area—for example, the Sappa Creek field, Rawlins County, and the Rueb field, Cheyenne County. The Rueb field, 30 miles

(Continued on page 45)

CLASS NOTES

(Continued from page 36)

Co. of Calif., has moved from La Habra, Calif., to Vernal, Utah. His P. O. Box is 455.

John Sulzbach is project manager trainee, Heavy Construction Division, Henry J. Kaiser Co. He lives at Apt. 5, 451 Wayne Ave., Oakland 6, Calif.

M. Donald Wagner is production engineer for Mobil Oil Co. de Venezuela with mailing address Apartado del Este 5393, Caracas, Venezuela.

1957

Guymon E. Adams is geophysical interpreter for Creole Petroleum Corp. He has moved from Pleasant Grove, Utah, to Caracas, Venezuela, where his mailing address is c/o Creole Petroleum Corp. Geofisica, Apartado 889.

John P. Allen, department head for Union Carbide Nuclear Corp., has moved from Tarentum, Pa., to Uravan, Colo.

Robert T. Beckman, mining engineer in the Division of Mineral Resources, U. S. Bureau of Mines, has moved from Julesburg to 701 S. Emerson, Denver 9, Colo.

William T. Larsen has left Mountain View, Calif., for 2446 Walnut Grove Ave., San Jose 28, Calif.

Dale L. Pinkerton was recently transferred to the Denver office of Ingersoll-Rand as mining and construction representative in the Colorado and northern New Mexico area. For the past 2½ years Dale has been with the New York headquarters office of Ingersoll-Rand as sales engineer in the rock drill department. The Pinkertons, now a family of four, have their home at 6447 Lee St., Arvada, Colo.

Z. A. Sancevic, exploitation engineer for Cia Shell de Venezuela Ltd., is on leave to take graduate work at Pennsylvania State University, College of Mineral Industries, Planning Department, University Park, Pa.

Kenneth A. Wagner, petroleum engineer for Amerada Petroleum Corp., has moved from Manhattan, Kans., to Charlston, N. Dak. His P. O. Box number is 77.

Charles R. Wood has been promoted from second lieutenant to first lieutenant. His mailing address is 1st Lt. Charles R. Wood 05504462, Hq. 79th Engr. Gp. (Const.), Ft. Belvoir, Va.

1958

Douglas P. Hildenbrandt has moved from Greeley, Colo., to 1416 E. Fair Oaks Ave., So. Pasadena, Calif.

Glen D. Cheney, office engineer for Ingersoll-Rand Co., has moved from Bairoil, Wyo., to 820 Simms St., Golden, Colo.

Bruce E. Russell, mine geologist for Cliffside Mine, Phillips Petroleum Co., lives at 431 N. Iron St., Grants, N. M.

Peter J. Sanger has moved from Purcell, Okla., to 4225 S. Broadway, Englewood, Colo.

William H. Wahl has moved from El Cerrito, Calif., and now lives at 2555 Duke, Richmond, Calif.

Ens. Charles J. Wideman, 2707 E. Adams St., Tucson, Ariz., graduated Nov. 20 from the Navy's Officer Candidate School in Newport, R. I. He was one of 722 officer candidates to complete the 18 weeks of intensive training in the naval sciences.

1959

William D. Gay, mining engineer for Union Carbide Nuclear Trace Elements Corp., has moved from Maybell, Colo., to 6th and Green Sts., Craig, Colo.

Robert A. Lame's address is 1143 E. Garvey Blvd., West Covina, Calif.

Ensign Craig S. Martenson graduated on Nov. 20 from the Navy's Officer Candidate School in Newport, R. I. His mailing address is 180 Oaks Rd., Framingham, Mass.

Charles H. McKinnis is a second lieutenant in the U. S. Army. His mailing address is 95 Brentwood, Lakewood, Colo.

Gary E. Melickian, a graduate student at the University of California at Los Angeles, has moved from Sylmar, Calif. to 212 Bonita, Apt. 8, Arcadia, Calif.

Mr. and Mrs. Steven L. Milne announce the birth of a son, Scott Alan, Nov. 29. The Milnes live at 2325 28th St., Boulder, Colo.

Douglas M. Ross has moved from Golden, Colo. to 1416 E. Fair Oaks Ave., South Pasadena, Calif.

James R. Swaisgood is on a six months tour of duty with the U. S. Army. His mailing address is Box 402, Rt. 3, Ft. Collins, Colo.

Richard T. J. Whittington's address is 1304 E. Jax, Midland, Texas. He is employed by the R. H. Ray Geophysical Co.

Mr. and Mrs. George N. Brown, Jr., are parents of a daughter, Janel Rene, born Nov. 24 at Kadlec Hospital in Richland, Wash. Mrs. Brown was the former Miss Joyce Rapp of Golden. Mr. Brown is employed in Reactor Technology and Operations with General Electric Co. at the Hanford Atomic Products Operation in Richland.

1960

B. Frank Porter, who receives his E.M. degree in January 1960, has become the first active member of the Alumni Association of the Class of '60.

ADDRESS CORRECTION NOTICE

To receive your Mines Magazine regularly—keep us advised of your correct address.

Name ______________________

Address ______________________

Position ______________________

____

Company Connection ______________________

____

____

USE FOR CLASS NOTES

You want to read about Mines Men. *They* want to read about you.

Address: Colorado School of Mines Alumni Assn., Golden, Colo.

BOOK REVIEWS

(Continued from page 44)

from the nearest producing area, gave Cheyenne County its first commercial oil production.

Copies of "Oil and Gas Developments in Kansas During 1958" (Bulletin 138) may be obtained for $1 each from the State Geological Survey, The University of Kansas, Lawrence, Kan.

Survey of Canadian Iron Ore Industry During 1958

The Department of Mines and Technical Surveys, Mineral Resources Division, Ottawa, Canada, offers Mineral Information Bulletin MR 31, by T. H. Janes and R. B. Elver, price 50 cents.

This publication provides a detailed study of the production, trade and developments of the iron ore industry in Canada during 1958. Maps showing the properties in production, properties under development for production within the next few years, and properties on which exploration of iron-bearing material is taking place are included. The text is supported by tables and graphs dealing with production, consumption, and trade in iron ore.

PLANT NEWS

(Continued from page 42)

he became president and a director of Dorr-Oliver Inc. During World War II, Mr. Hitch served as a civilian technical advisor in China for the U. S. Government.

Mr. Boling joined the company in 1941 following eight years with California Spray Chemical Corp. A graduate of the University of California, he served successively as assistant controller, controller, secretary and treasurer of the former Oliver United Filters organization. When they merged with The Dorr Company in late 1954, he became vice president for finance and a director of the new corporation. On Jan. 1, 1959, he became vice president for operations coordination and on June 15 was elected executive vice president and chief executive officer.

Gardner-Denver, Apex Will Merge on March 1

G. V. Leece, president of Gardner-Denver, has announced that Apex Machine & Tool Co. of Dayton, Ohio will become a wholly-owned subsidiary of Gardner-Denver on March 1, 1960.

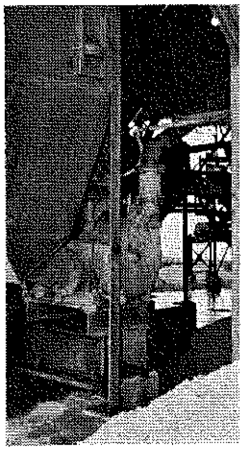
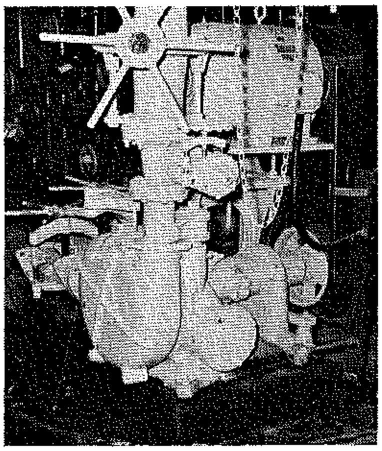
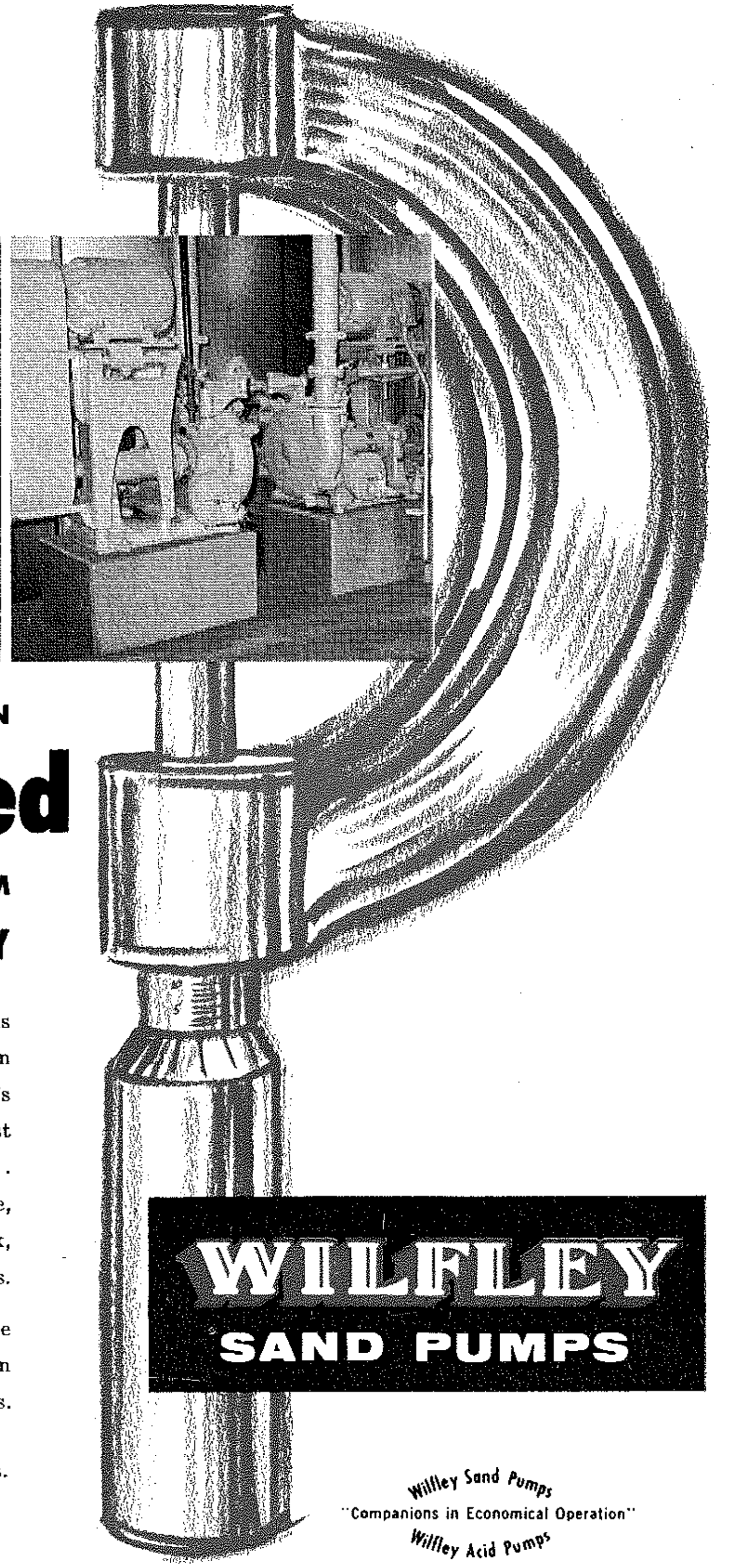
Apex is a leading manufacturer of screwdriver bits and sockets for power tools. The company also is an important producer of universal joints for machinery and aircraft. In Gardner-Denver's line of equipment for industrial production are power screwdrivers and nutsetters that utilize Apex bits and sockets.

Gardner-Denver is celebrating its Centennial this year as a world-wide industrial firm.

Clarence Thom Will Be Consulting Metallurgist

Clarence Thom, director of the Denver Equipment Co.'s Ore Testing Division for nearly 25 years, has assumed new responsibilities, consulting metallurgist for Denver Equipment Co. and their many customers.

ADVERTISERS' LISTINGS

EVERY INSTALLATION

Job Engineered

FOR MAXIMUM

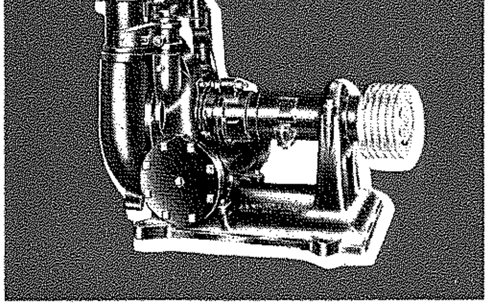
PUMPING ECONOMY

Individual engineering on every application is standard practice with Wilfley. This personal attention to your specific requirements, plus Wilfley's day-in, day-out dependabilty, guarantee low cost pumping. Put a Wilfley Sand Pump to work . . . it will give you continuous, maintenance-free service, higher output, longer pump life, and quick, easy replacement of parts.

Wilfley Sand Pumps may be fitted with interchangeable electric furnace alloy iron, special application alloys, or rubber-covered wear parts.

Write, wire or phone for complete details.

Wilfley Sand Pumps
"Companions in Economical Operation"
Wilfley Acid Pumps



A. R. WILFLEY and SONS, INC.

DENVER, COLORADO, U.S.A. - P.O. BOX 2330
NEW YORK OFFICE: 122 EAST 42ND STREET, NEW YORK CITY 17